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Philadelphia Meeting of the American Electrochemical Society.

After five years the American Electrochemical Society came back to its birthplace, Philadelphia, for the annual convention of 1907. Five years ago the leading electrical engineering journal of this country commented on the Society's inaugural meeting as having been "of such a high order of merit that to keep future meetings up to the standard there set may become a difficult task." This prophecy has come true. But difficulties never prevent success when there is an earnest will to attain it. In spite of the ups and downs which are natural in any case, the course of the American Electrochemical Society has been in the main decidedly an upward course. The Society has undoubtedly done useful work; it has fulfilled the purpose for which it was founded, "the advancement of the theory and practice of electrochemistry." Through the personal intercourse of members at the meetings theorists and practical men have learned to understand each other better, and a sound professional solidarity of all workers in the field of electrochemistry has been produced. Through its *Transactions* the Society has strongly and successfully appealed to its whole membership and even to a much greater circle of readers. In spite of their intrinsic value there is, however, a decided possibility of improving the *Transactions* by extending the discussions of the papers. A stricter censorship from an appointed committee is a doubtful remedy. More thorough critical discussion from the membership at large is a far better thing. But this cannot be obtained unless all papers are printed well in advance and distributed. If then the rule is established (as at the last convention of the Iron and Steel Institute) to allow any author not more than ten minutes to summarize his paper, there will be time for a good discussion—friendly and otherwise, orally and communicated—and the *Transactions* will greatly gain in interest.

* * *

The meeting in New York last Autumn had been a frost, due to a series of unfortunate circumstances which prevented early and proper arrangements and announcements. The meeting in Philadelphia last month was a splendid success. It showed decidedly that the Society is still young and healthy and strong. The program was well balanced in all its features. Undoubtedly there were too many papers on the program for proper presentation and discussion, but this will be no disadvantage for the *Transactions*. Several illustrated lectures on broad subjects, by Dr. E. F. Smith on his work in electroanalysis, by Dr. C. P. Steinmetz on electric conduction, and by Prof. A. T. Lincoln on corrosion of brass, proved exceedingly interesting, and the policy of inviting such lectures should be continued. A great number of highly instructive excursions and visits had been arranged for the afternoons, and as to the purely social features the Philadelphia meeting was certainly as enjoyable as any meeting ever held by the Society, in the sense of the old and sound maxim of Goethe, "Tages Arbeit, Abends Gäste, saure Wochen, frohe Feste."

In view of this success of the meeting, which indicates that the Society has entered into a new era of usefulness, surprise has been expressed in many quarters at the serious discussion of a proposition which threatens the very independence of the Society. It has been made to the American Electrochemical Society by the American Chemical Society. It is proposed that all papers on physical chemistry and electrochemistry read before either Society should be published in one monthly journal under supervision of a joint board. The advantages are evident. The members will receive more for their money. Further, the relative expense of publication will be reduced. In fact, were a scientific or engineering society to be run as a commercial enterprise, all the advantages of modern industrial trusts could be urged for such a combination. However, there are complications. Even those who are in favor of the plan do not agree as to how it should be carried out. Mr. Hering has suggested an elaborate but just system of distributing expenses. The other side proposes the Electrochemical Society should pay a flat sum for each member to the Chemical Society. The first proposition was $3 per head. This has now been reduced to $2. In view of this change one wonders how long such an agreement would last. Further, a joint publication board of six is proposed, three from each society, and an editor. Evidently the editor would have the decisive vote. It is impossible to see how to combine this with Mr. Hering's stipulation that the Electrochemical Society should not subject its papers to the censorship of another Society. The *Transactions* are the Society's chief asset from which it derives its standing and individuality. However the above proposition may be carried out the continuity of the *Transactions* will be lost. The necessary consequence will be the loss of identity of the Society itself, which will become the electrochemical section of the American Chemical Society. Those who have worked most enthusiastically for the Society will hardly like this consequence. The Electrochemical Society has come into existence because differentiation and specialization are the keynote of all modern progress in science and engineering. It would not be wise for the Society to take a step now which it cannot take back should it ever desire so. But we have not the slightest doubt that should the question ever come before the members for a mail vote, the Society will be saved by the esprit de corps which it has inspired in the rank and file.

Some Aspects of Sodium Chloride Electrolysis.

An electrochemical reaction cannot be fully understood if looked upon from the standpoint of pure chemistry. Electrochemistry is essentially physical chemistry. Starting with the same chemical reagents it is possible to obtain quite different products by changing the electrical and, in general, the physical conditions of the operation. The classical example from electric furnace practice is the reaction between silica and carbon which has resulted in building up the industries of carborundum, siloxicon, artificial graphite and metallic silicon. An equally instructive example from the field of electrolysis is the decomposition of sodium chloride by the electric current. Starting with the same materials we obtain in cells of different construction chlorate or hypochlorite or chlorine and caustic soda. The conditions for the production of the latter are intrinsically different from the other two cases in so far as it

is of fundamental importance to keep the produced chlorine and caustic soda separate from each other so as to prevent any reaction between them. For the purpose of electro-analysis, Dr. Edgar F. Smith has devised an ingenious method of absorbing the chlorine by means of silver anodes and the sodium by means of the mercury cathode. On a large commercial scale where the object is to produce caustic soda and chlorine in ton quantities the absorption of the chlorine has never been attempted while the use of the mercury cathode in the Castner-Kellner cell has assumed immense industrial importance. The Acker process of electrolyzing fused sodium chloride and alloying the sodium with a fused lead cathode is in principle absolutely analogous to the mercury cathode process.

*   *   *

If the sodium set free at the cathode is not carried out of the sphere of action, but remains in solution in form of caustic soda the electrochemical system is changed. We have at the cathode no longer sodium chloride but a mixture of sodium chloride with sodium hydroxide, so that not only chlorine ions but also hydroxyl ions are migrating from the cathode to the anode. To prevent the hydroxyl ions from reaching the anode and causing trouble there, is the problem of the Glocken process, or gravity process, and of the different types of diaphragm cells. The theory of the Glocken process had formerly been based on the pretty assumption that the fresh solution which is continually being introduced into the anode compartment flows downwards in the bell with the same speed as that with which the hydroxyl ions tend to move upward toward the anode. That this explanation is wrong has been clearly shown in the interesting article of Dr. Steiner published in our last issue. There the correct explanation is also given. In the case of diaphragm cells the diaphragm had first been relied upon to prevent a mixing of the anolyte and catholyte. While mechanical mixing can thus be avoided, a diaphragm cannot prevent the migration of the hydroxyl ions toward the anode. For this reason further devices have been used in the highly improved diaphragm cells of modern construction; for instance, the electrolyte is forced from the anode compartment into the cathode compartment through the diaphragm so as to counteract to some extent the tendency of the hydroxyl to move in the opposite direction.

*   *   *

The Townsend cell which has been in successful use for a year in Niagara Falls, as described in the interesting paper by Dr. Baekeland in our present issue, is generally called a diaphragm cell. It is true, it contains a diaphragm, but the effect of this diaphragm is very different from that in the ordinary diaphragm cells. In the latter the diaphragm separates the anolyte from the catholyte, and both the anolyte and the catholyte form the electrolyte. In the Townsend cell the diaphragm separates the sodium chloride solution under electrolysis from inert liquid kerosene; there is no real catholyte. In the ordinary diaphragm cells the caustic soda is in solution in the catholyte, and remains therefore within the sphere of electrolytic action. In the Townsend cell the caustic soda is absorbed in the kerosene and carried off and immediately removed from the sphere of electrochemical action. In this respect the Townsend cell stands really nearer to the mercury cathode cell than to the ordinary diaphragm cell. The hydro-

gen gas which is set free together with the caustic soda, and which in other cells has been troublesome in mixing the electrolyte on account of its stirring effect, is used in a very pretty way in the Townsend cell to produce just the opposite result, namely, to help carrying the caustic soda away from the solution as soon as formed.

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Concerning Rail Metal.

Those who are not familiar with the ins and outs of making, selling and buying steel rails are in danger of being led to conclude that the strenuous discussion being carried on in the public prints relative to Bessemer and open-hearth rails, carbon, phosphorus and what not, and the diversion from Northern rail mills to the Southern rail mill of orders of railroads naturally tributary to the Northern mills, involve purely a metallurgical point. They are likely to assume that the steel metallurgist is being called upon to devise ways and means of making better steel rails. While this is true, it is by no means the whole truth. The American rail trade has for a number of years past been managed on the principle of "you tickle me and I'll tickle you." The participants in the game have been all the rail mills (but the one located in Alabama) on one side and all the railroads, which handle large iron and steel freight tonnages on the other side. The railroads which are not so located as to be able to obtain large iron and steel freight tonnages have been interested but increasingly disgusted spectators. The Alabama rail mill has also been an interested spectator, but an increasingly satisfied one.

* * *

It may be doubted whether those responsible for the fuss about rail metal in the newspapers have ever speculated upon the modus operandi by which rail orders, sometimes passing the hundred-thousand-ton mark, are placed. Did they by chance devote some consideration to this question they would probably ratiocinate that the negotiations would be conducted by the engineers of the respective parties, the railroad engineer on the one hand drawing from the large fund of knowledge he is well known to possess as to rail breakage, endurance, etc., and the steel works engineer on the other hand, employing his knowledge of the results in quality of different materials and processes involved in the making of a steel rail. However comforting to one's intelligence as a thinking animal and reassuring to his bodily safety as an occasional or frequent passenger on railroad trains such a reasoning may be, it is erroneous. The bulk of the large rail orders are not so negotiated. The operation is usually conducted by the president of the railroad on the one hand and the chief executive or fiduciary officer of the steel-making interest on the other. Did walls have ears, which for the comfort of these important parties they have not, they would probably be in position to repeat such words as reciprocity, tonnage of freight, freight rates, etc., all quite kindred to the subject of conducting business, but not altogether kindred to the metallurgical question of making good rails. We doubt whether in such negotiations much use has been made of such words as carbon, phosphorus, segregation, cropping, drop tests, etc. These subjects were invented to amuse the engineers on the respective sides and enable them to earn their salaries, so that their consciences would be easy. The placing and filling of rail orders has been,

usually, no place for the application of this knowledge. We have referred to the first act, that of placing the orders. The second interesting act, that of making the rails, must be read by title. The third, that of inspection, is believed to have occasionally taken the form of the young man delegated for the purpose by the railroad giving the rail-mill superintendent a good cigar, to invite the needful instruction as to how the inspection should be conducted. The last act comprises the use of the rails, the final scene being where the rail breaks, and then the curtain drops, whereupon the newspapers begin throwing eggs of doubtful antiquity.

* * *

Which act of this drama, involving millions of tons of steel and tens of millions of dollars a year, is it which should invite this shower of missiles? We submit with due deference to the so hasty judgment of a large part of the public that the missiles should have been thrown at the end of the first act, with insistent calls for the appearance at the center of the stage during that act of one who should be the chief dramatis persona—the metallurgist. Then, should the play proceed to the third act, that act should not be allowed to be concluded unless this gentleman were accorded the center of the stage throughout the act. The fourth act would then be much more agreeable to the millions of people personally and bodily involved. It is not alone the direction of this popular thought, now that we are at it, with which we desire to find fault. Its foundation is largely erroneous. One would suppose that to the enormous loss of life by reason of the operation of American railways defective rails are the chief, or at least a very important, contributor. It is not so. The reports of the Inter-State Commerce Commission for the second half of last year show a total number of persons killed of 2,612. Of this number 741 were killed in train accidents, and of these 741 there were only 22 who were killed as a result of "defects in roadway." The statistics of the Commission are not further sub-divided in the quarterly reports, so that it is impossible to state what proportion of these 22 were killed through defective rails. Certainly there are other defects of roadway than those due to defective rails. It is sufficiently instructive to observe that the railroads in six months killed 2,612 persons, but less than 22 in accidents due to defective rails.

* * * *

Years ago, if the railroads had insisted upon a lower phosphorus content, liberal cropping of the ingot and proper heat treatment as to finishing, they could have gotten these desiderata in Bessemer rails and the rails would have been sufficiently good. Now it is impossible to get the phosphorus down, because low-phosphorus ores are playing out, and instead of selecting the lower-phosphorus ores for rail making the producers must keep them to mix with higher-phosphorus ores, making steel which is outside, or just inside, the commercial phosphorus limit, according to the diligence of the buyer. The result will be the open-hearth rail, and it would not seem to be visionary to think of a further step—the combination of the open-hearth process with some cheap electric refining and mixing treatment, as outlined in connection with the letter of a correspondent on another page of this issue. But, as we tried to point out, the full improvement of the situation involves commercial as well as metallurgical changes.

Iron and Steel Institute.

The thirty-eighth annual general meeting of the Iron and Steel Institute was held in London on May 9 and 10. In the absence of the retiring president, Mr. R. A. Hadfield, who is at present in the United States, Sir James Kitson opened the meeting. From the report of the Council it appears that on Dec. 31, 1906, the Institute had 2,052 members. After thanks had been voted to the retiring president and Council, Sir James Kitson introduced the new president, Sir Hugh Bell, into office.

The first official function of Sir Hugh Bell was the presentation of the Bessemer gold medal to Mr. J. A. Brinell, of Stockholm. Sir Hugh Bell then presented his presidential address, dealing with the progress made during the past hundred years in the manufacture of iron and steel, and especially with the influence of greater transportation facilities on the industry.

A full report of the papers presented at the meeting will be given in our next issue. All of them elicited quite an animated discussion. This was rendered possible by the new rule, adopted by the Council, to print and distribute copies of papers in advance and allow an author not more than 10 minutes to give a summary of his paper for introduction of the discussion.

The Iron and Steel Market.

A great deal has happened in pig iron since our last report. The modest suggestion in that report that there were "prospects that regular consumers will easily absorb all the available tonnage" in Bessemer and basic pig iron for this year's delivery has been borne out, as all the iron which producers could offer has been taken up, prices have advanced $2 or more per ton, and middlemen are about the only sellers, and then only in small lots. The Southern iron market, which was then "firm at $18.50 for second half," has advanced by jumps to $21.50 for third quarter and $20 for fourth, with $18.50 quoted for first half of next year.

Where this will all end is a subject of anxious thought for producer and consumer alike. It is improbable that any drop can come within the next three months, as production invariably declines through the hot weather from meteorological conditions, but for the late months of the year all is in doubt in the minds of consumers. If producers are not also beset with doubts it is curious that they refuse to accept orders for third quarter only at their second half price, requiring the buyer either to pay a premium for the third quarter alone, or take deliveries over the whole half.

The rail market for 1908 delivery has been opened, but orders are not coming in as rapidly as they usually do, the first four weeks of business showing only about 700,000 tons, including the tonnage of the Tennessee Company, which took orders before the Northern mills opened their books.

Specifications are coming in a little less rapidly than they were. Producers are indisposed to admit the fact, and make much of some new buying of steel bars by agricultural implement makers and other interests.

The condition is one which should be studied with the utmost caution by one who wishes to arrive at a correct diagnosis. Producers wish to squeeze out the last ton of orders possible from all existing contracts, and therefore have a great deal at stake in the continuance of popular confidence.

Much is said now, and much has been said in the past few years, about the extremely beneficial effect of the steadying policy of the United States Steel Corporation, and the application of the principle to what would otherwise be a period of depression. There is a fallacy in this. Similar influences will produce similar results in similar conditions, but not necessarily in dissimilar conditions. What has been shown is that in a period which would otherwise be one of mild fluctuations in demand and prices, the influence of the steel corporation produces steady demand and steady prices. This proves noth-

ing as to results in a period which would otherwise be one of serious depression.

Let the previous state of the market be represented, as to demand, by a curve. It will show moderate ups and downs over short periods, of months or at most one or two years, with a grand swing up and down over ten-year periods. Now the influence of the steel corporation with its steady prices has been to eliminate these little movements. A prospective consumer sees that there is no prospect of any decline in the next year, and so he buys at once. Space is being borrowed from the future to fill up the little valleys in the curve, making a straight line along the peaks. It has not been shown that demand is created, merely that it is anticipated. Where can space be found to fill up the big valleys in the ten-year periods? Indeed, one is tempted to conclude that the anticipations of demand are going to make the depression all the more severe when it does come. Consumers have come to lean upon the steady arm of the steel corporation. When that support is withdrawn where will their dependence be?

These observations may be premature. The iron and steel trade is wound up to run well through the year, and on the surface is more prosperous now than it was a month, two months or three months ago. Possibly something may occur to carry the activity still farther, but the end of this high pressure must come some time, and the beginning of the end may be now.

Pig Iron.

Production has been steadily on the increase, due to the blowing in of idle furnaces and the completion of an occasional new one. A decline must come with the hot weather. While deliveries are fairly good, spot iron is quite scarce and commands high prices. As high as $30, Central Western furnace, has been paid for both No. 2 foundry and Bessemer in carload and 50-ton lots. Foreign iron continues to be a factor all along the seaboard, and is penetrating farther inland than before. There is more uncovered than unsold tonnage to Oct. 1, but beyond that date the situation may be quite different. The market has been advancing so that transactions a few days old no longer give a cue to the market, and we shall merely remark that while sales have been fairly large they have scarcely been up to normal, and then quote prices at this writing as follows, f. o. b. Central Western furnace: Bessemer and basic for June delivery, $24, in moderate sized lots and higher in small lots, for second half $23 to $23.50; No. 2 foundry, $25 and higher for June, $24 for third quarter, and $23 to $23.50 for fourth quarter or second half; gray forge $22. Some sales of foundry, malleable Bessemer and forge have been made for 1908, but none of Bessemer or basic. The Southern market is $21.50, Birmingham, for third quarter and $20 for fourth quarter, with $18.50 quoted on some inquiries which have been received for the early part of 1908.

Steel.

The Carnegie Steel Co. named $31 as the settlement price for June deliveries of sheet bars on monthly adjustment contracts. This is the minimum of the market. Purchases have been made from other mills at this figure for fourth quarter, and other orders have been offered and refused. Billets are not quotable accurately, being nominally about $30.50 for Bessemer and $32 to $33 for open-hearth at mill. The available supply of all crude steel is extremely limited. A peculiar condition has existed for several years, a period amply long to make the market forget that it is not necessarily permanent. That condition is that demand has been uniformly good for all finished steel products in proportion to the existing finishing capacity. Formerly the alignment was that there was a necessary excess of total finishing capacity relative to steel making and pig iron producing capacity. Finishing mills were then more flexible as to character of output than they are now. The present large finishing units are adapted to but a limited range. The finishing capacity is not only less flexible but more closely

approximates to the steel making and pig iron producing capacity. The time must come when demand for finished products will show more variation; some finishing departments will be filled with business and others will not. That will throw crude steel upon the market in a manner and volume never seen before, but the trade does not seem to have a glimmer of thought that such may be the case.

RAILS.

The Tennessee Coal, Iron & Railroad Co. will make about 350,000 tons of open-hearth rails in 1908, and has sold nearly all the tonnage. Surprise was caused when the Harriman lines, more naturally tributary to Chicago than to Alabama, placed 150,000 tons with the Tennessee company, avowedly because the product was open-hearth. The Harriman lines have had an unusually large number of broken rails, but it is probable. that other influences, quite apart from considerations of quality, contributed to the decision. The Northern rail mills opened the order books for 1908 orders on April 17, and in the first four weeks booked fully 400,000 tons, the orders not coming in as rapidly as usual. The price of the Northern mills remains at $28, mill, where it has been since the spring of 1901. The Tennessee company advanced its price from $29 to $30, Birmingham.

FINISHED. MATERIAL.

There has been a slight but significant decrease in the volume of new business and specifications on old contracts. The large mills insist that with absolute tonnage booked and reasonable prospects on contracts they have with steady consumers, their entire tonnage for this year is taken care of in shapes, plates and merchant steel bars. In wire, pipe and sheet products the mills are booked solidly for from three to five months, giving them enough momentum to carry them through the year, with a continuance of moderately favorable conditions. The market lacks the snap which it had, but on the surface appears perfectly sound.

The only change in prices, and that more or less a nominal one, comes through the issuing of a new list on merchant steel pipe by the leading interest, which fixes the inside price to jobbers at 74 and 5 off, on sizes ⅜ to 6-inch, an advance of 2 points, or about $4 a net ton, on the list which was withdrawn March 8 last. The price is retroactive, a large tonnage having been booked *ad interim*, subject to such prices as should be announced later. Early deliveries command a point higher price, the independents only promising anything in the way of early deliveries. We quote other products unchanged, except that common iron bars are down $2 a ton for Pittsburg delivery and $1 a ton for Western delivery. Prices quoted are f. o. b. Pittsburg:

Structural shapes, $1.70 for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality; early deliveries command premiums.

Merchant steel bars, $1.60, base.

Common iron bars, $1.70, delivered, Pittsburg; for Western delivery, $1.60 f. o. b., Pittsburg.

Sheets, 28 gauge, $2.60 for black, $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

CORRESPONDENCE

The Electric Furnace in the Foundry.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—I was very much interested in the letter of Mr. P. McN. Bennie, with reference to the electric furnace in the foundry, which appeared on page 75 of your March issue. Lack of time in connection with the convention of the American Foundrymen's Association, has prevented me from adding a few words in further explanation of my original suggestions.

Mr. Bennie, in his Philadelphia lecture, referred to the possibility of placing an electric furnace in the foundry with the idea of taking some of the melted iron from one or more cupolas and refining it to steel. In other words, to utilize the regular run of metal for small steel castings. I am afraid that this would not be practical for the ordinary foundry, inasmuch as the metal used for gray iron castings would not be suitable for steel making. If the electric process is carried on in an acid lining the "fancy" irons would have to be used with the attendant evil of sulphur additions, due to melting in the cupola. If the basic lining is used the phosphorus and sulphur might be cared for, but the other constituents might make trouble, as they are not properly proportioned for steel, if right for cast iron; that is, judging from the ordinary methods of making steel.

I am afraid that to make steel castings by refining the metal in the electric furnace on a small enough scale for the ordinary foundry would cost too much for skilled labor, while the works with larger demands for steel castings would naturally avoid a process costing more than $45 a ton for castings when pig iron is about $26.

As I see it, only a process taking scrap steel castings of an approximately correct composition, heating this up to white heat in an ordinary heating furnace, transferring it to the induction furnace, melting, adding the necessary ferromanganese, etc., and pouring, would find favor in the foundry.

So far as brass is concerned, the induction furnace would seem ideal. Any one who has had to do with the various types of oil-burning furnaces, knows that while they are mighty convenient the loss of metal is not only very great, but for certain classes of castings it is impossible to get sound results on account of the excessive oxidation. This is for the furnaces in which the gases play right on the metal. The crucible process is bad enough, and only the fact that the greatest care is taken with the metal used, and the adding of the easily oxidizible materials last, makes this old-fashioned and withal reliable method passably good. Where very thin scrap is used in the melt I have known 50 per cent to go up the flues.

Now, taking the induction furnace for this line of work, one can readily see advantages which, if some electrical concern would tackle the problem, would result in driving out all other forms of brass melting. With the temperature, a matter of regulation. With the atmosphere of the melt, non-oxidizing. With the taking up of foreign matter in a slag and the whole operation so self-contained that it is clean enough for the office. With practically no loss of metal during the melt, and the possibility of using 97 per cent of scrap and 3 per cent manganese as a final purifier, or the equivalent in manganese-copper, suppose the current does cost twice as much as the coke otherwise consumed, or even more. In the gray iron foundry the coke, or fuel, is by far the smaller end of the expense entering the cost of a casting. In brass melting this is not quite the case, but the loss of zinc or tin is so costly a matter that it would quite overbalance a higher fuel charge.

We of the foundry industry certainly await developments that I understand are in process even now, with the greatest of interest from both the commercial standpoint and that of a distinct advance in a great industry.

WATCHUNG, N. J.   RICHARD MOLDENKE.

The Breakage of Steel Rails.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—According to newspaper reports a number of engineers attribute the frequent breakages in steel rails entirely to a faulty or careless system of rolling. I do not think that experienced practical steel makers coincide with this. If it was really due solely to rolling the breakages would be more universal and not exceptional, as in the mechanical operation

of rolling all rail products of the same section are being treated alike.

As a matter of fact, the trouble seems to be due principally, to metallurgical defects in the steel. Practically all rail steel is being produced either in Bessemer converters or in basic open-hearth furnaces. These processes are of such a nature that the gases and the slag, resulting from conversion, cannot be entirely eliminated. Wherever these particles remain, and they may be distributed all through the rail, the steel is weak.

Without going into details, experience has taught that it is useless trying to correct these faults by mechanical means. It might improve the steel ingot to some extent, but it will never be equal to an ingot that has been cast thoroughly solid. As has been suggested, the weight of the rail might be increased by 20 to 30 per cent. Undoubtedly, this would give additional security, but to my mind it will not remove the principal cause of the trouble.

I am sustained in all the foregoing by the fact that in most cases of broken rails, whenever the question arose, whether the accident was due to faulty rails or extra hard wear, the only reliable tests made by the railroads to place the responsibility was by means of tests that positively proved that the steel rails were contaminated with oxides and slag in those parts that were responsible for the collapse.

I quote from an article by Mr. Robert Job in *Cassier's Magazine,* May issue:

"A short description of the method used to determine the cause of a rail failure may be of interest. In some cases, as, for example, when a bad pipe is present, the cause is evident at a glance. In other cases the prime cause may not be clear. An instance will point our meaning. A number of rails had mashed down in track after a few months' wear, and the mill refused to make replacement, claiming that the difficulty was due to the hard conditions of service. In order to determine the matter we took a representative section from one of the rails, polished the surface and etched for a few seconds with a solution of iodine. The characteristic appearance proved that the steel was so seriously contaminated with oxides and slag that little tenacity could be expected, and the wonder was that the rail had held together even as well as had been the case. With this evidence in hand the mill made proper replacement without further question.

"In some cases the condition of the rails adjacent in track may give some indication as to the cause of failure. In one location where a considerable number of rails had failed, it was found that both bad and good rails from the same rolling were in the same line of track adjoining one another and under precisely the same traffic conditions. A number of each type were removed and investigated. Analysis gave no clew, but upon light etching of the polished surfaces it was found that in every case in which failure had occurred the steel was unsound, whereas in every case in which normal results had been obtained the steel was almost perfectly free from this defect of unsoundness. We next examined the polished surface of the unsound steel under the microscope, and found that large numbers of holes and of oxide spots were present, and, in order to get the condition more clearly, we fractured the head of the rail along its length, and found that a large number of seam lines were present. In service the heavy wheel loads naturally forced the steel apart at these unwelded seams and thus caused the rail to crush. In the light of this evidence the true cause of the service failure was evident, and suitable action was taken by the mill in question."

Whatever trouble may be due to insufficient cropping of ingots, or faulty system of rolling, the steel makers are in position to remedy. It is, however, difficult to prove that the frequent rail breakages are due to these causes, whereas the presence of oxides and slag has been and can be established beyond doubt in most cases. With the present methods of making rail steel in Bessemer converters and basic open-hearth furnaces, it is however, impossible to produce a pro-

duct absolutely free from oxides and slag. The only way to accomplish this and produce a uniform rail steel as well would be by passing the hot metal as it comes from the converter or open-hearth furnace through a large vessel free from oxidizing flames, for the purpose of keeping same at a dead melt and refining it.

It must also be borne in mind that owing to increased service requirements steel makers have been compelled to produce rails of much higher carbon, hence the metallurgical defects to which the main trouble is due are more aggravated, owing to the high carbon steel containing phosphorus and sulphur, the two most dangerous elements, considerably over .03 per cent. This might not be of such great consequence if steel rails were free from oxides and slag, but when all these dangerous elements happen to be combined trouble may surely be looked for.

The whole question resolves itself into this: Can steel rails be produced containing from .80 to 1 per cent carbon, phosphorus and sulphur not exceeding .02, and free from oxides and slag? If steel rail makers can guarantee to supply such an article to the railroads it would not only be the best guarantee for safety, but such a rail would outlast the present article bought by the railroads by many years, and they could easily afford to pay a higher price for such rails, as it not alone would mean a saving of life and limb, but great economy for the railroads in the long run.   STEEL ENGINEER.

NEW YORK CITY.

[The above letter of our correspondent is suggestive in various respects. In order to improve the rail metal we can either employ a special alloy steel or we can retain the ordinary steel and improve the metallurgical treatment of the metal in other respects. Nickel steel has been suggested, but at present its use or the use of other alloy-steels seems prohibitive on account of the expense. In discussing the rail-metal problem on another page of this issue, we have explained why we believe that the open-hearth rail is to come. But some points employed in the above letter of our correspondent suggest a further step; namely, the use of an electric furnace refining treatment subsequent to the open-hearth process. If such electric treatment is to be commercially successful it must be cheap, and to obtain the best results it must be a very large-scale operation. This suggests an electric steel mixer rather than an electric refining furnace. Dr. Héroult has pointed out and discussed the possibilities of such an electric steel mixer on page 30 of our Vol. IV.; and on page 173 of our last issue we mentioned the installation of a 150-ton steel mixer in a German steel works, employing the induction furnace. However, in the case of rail metal, to get the best results the mixer should not simply keep the metal in molten state and mix it, but it should be possible to produce chemical reactions in the same. In other words, we should have a mixer and electric refining furnace in one and the same apparatus. Dr. Héroult's scheme of employing the open-hearth process for reducing the phosphorus content down to any desired amount and then treating the dephosphorized and highly oxidized metal from several open-hearths in one large electric mixer for desulphurizing, deoxidizing and recarburizing is a special method deserving the most careful attention of steel makers. A process of this kind is distinctly feasible; a uniform product of desired composition in carbon, phosphorus and sulphur can thus be obtained, free from oxide and slag, and the only question is that of cost. In view of the large size of the mixer the electrical energy required per unit of output should be relatively small, and could be produced at a minimum cost from gas engines if blast-furnace gas is available. Moreover, the electric process permits the use of less ferro-alloys than would otherwise be required. This means a saving which reduces somewhat the expense for the electrical energy. In view of the present situation, with respect to rail metal, electrical methods —such as that outlined above or others—should find the attention which they deserve from a metallurgical standpoint.— EDITOR.]

The New Electrolytic Alkali-Works at Niagara Falls.

At the last meeting of the New York Section of the Society of Chemical Industry, Dr. L. H. BAEKELAND read a paper on the Townsend cell. He gave a record of the practical performance the cell has made during a continuous operation extending over almost a year and a half, in a large plant, using 1,000 hp. This was the first public reference which has been made on the subject, and we are glad to be able to report to our readers some of the statements made by Dr. Baekeland.

The speaker began by referring to *Electrochemical Industry*, Vol. I., p. 23, where, as far back as 1902, C. P. Townsend outlined, in a masterly way, the theoretical principles and problems involved in the electrolytic production of alkali and chlorine. Consistent with his theory, Townsend solved the problem of the diaphragm cell in an entirely new way. Many believe that the failures of the diaphragm cells are due to rapid deterioration of the diaphragm, and numerous patents have been taken out in different countries, with the object of improving the construction of this diaphragm. Some inventors went so far as to dispense entirely with diaphragms; as, for instance, in the gravity cell, where anolyte and catholyte are kept separate by difference in density. In other cases, liquid metals, as mercury or molten lead, are used as cathodes, so that the liberated sodium metal can form an alloy or amalgam.

The main object in electrolytic cells should be to counteract the tendency towards recombination of the alkali-hydrate liberated at the cathode with the chlorine set free at the anode. Diffusion renders this recombination possible, and, for that reason, whatever will restrict diffusion will also retard recombination. Recombination does not merely involve a loss of energy efficiency, by permitting some of the valuable products set free by electrolysis to recombine again—it means much more. Whenever chlorine acts on alkalihydrate a mixture of alkalichloride and alkalihypochlorite, or even chlorate, is formed. These latter oxygen compounds are decidedly harmful; in their turn they are split by the electric current, and they disaggregate the graphite anodes by a process of oxidation. This explains the rapid corrosion of graphite anodes in some electrolytic cells. Frequent analyses of the anode liquor will show large amounts of hypochlorite and chlorate in cells which are badly operated. Dr. Baekeland mentioned the fact that a large amount of hypochlorite or chlorate in anode liquor was a direct indication of low ampere efficiency and rapidly deteriorating anodes. He stated, furthermore, that many inventors of electrolytic cells have given scant attention to the following principles:

FIG. I.—VERTICAL SECTION OF TOWNSEND CELL.

First. The rate of diffusion between anolyte and catholyte is a function of the concentration of the diffusing solutions.

Second. The amount of diffusion is a function of the time during which the given solutions remain in contact.

Third. The alkaline hydroxide, in contact with the cathode, takes part in the electrolysis, and the liberated hydroxyl-ions tend to migrate towards the anode, where they act oxidizing.

For these reasons gravity cells, working with an acceptable ampere-efficiency, give necessarily a weak caustic liquor.

Among the many attempts which have been made to reduce recombination to a minimum, Dr. Baekeland mentioned the

methods by which liberated sodium hydrate is transformed into less soluble or chemically less active compounds; as, for instance, submitting the cathode liquor to the action of carbonic gas, which transforms the alkalihydrate into carbonate or bicarbonate of sodium. He considers this transformation as a backward step, from a commercial standpoint, because it transforms high-priced caustic soda into low-priced carbonate.

He puts great stress on the fact that any cells, whether they be diaphragm cells or gravity cells, or liquid metal cathode cells, should not merely show favorable efficiencies. However high the latter may be they represent but partially the qualications of a good commercial cell. Even if a cell shows a maximum efficiency it may yet prove a commercial impossibility: if the cell is too delicate to be operated by men of average skill, or if the cost of maintenance and repairs is too
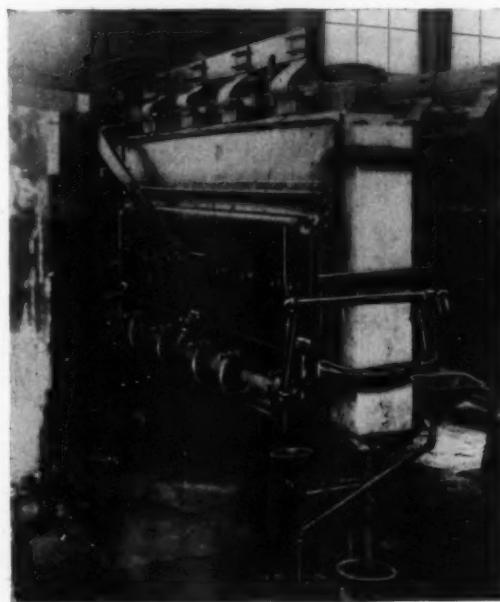

FIG. 2.—VIEW OF COMMERCIAL CELL.

high, or if the initial cost of the cell plant becomes exhorbitant.

He pointed out that many mistakes have been made by experts, eminently well qualified as scientists, but who accorded insufficient importance to the commercial side of a new cell, neglected to take these matters into consideration and thus rendered a too optimistic opinion. Instead of determining how good a given cell is under the best conditions they should have tried to find out what "hard knocks" the apparatus could stand; for that reason some experts had failed to detect inherent weakness which resulted later in commercial failure.

Townsend counteracts diffusion and recombination of cathions and anions by automatically substracting every drop of cathode liquor as soon as it appears, and surrounding it with a "chemically inactive and physically immiscible liquid." Kerosense is the liquid used in practice.

Lantern slides illustrated his lecture. Among them was one showing a diagram of a vertical cross-section of the Townsend cell (see Fig. 1). The anode space is enclosed between a lid (C), two vertical diaphragms (D), a nonconducting body (H) having the shape of a wide U (and of which only the section of the lower part is to be seen in the diagram); graphite anodes (G) pass through the lid of the cell and the protruding tops are connected by means of clamps to the electric generator; the diaphragms are in close contact with perforated iron cathode plates (S). The latter are fastened to two iron sides (I), bulging outwards in the middle,

which form what is called the cathode compartment. The anode space contains saturated brine (T), while the cathode compartment contains kerosene oil (K). On account of the difference in specific gravity between the two liquids there is a hydrostatic pressure from the anode compartment toward the cathode compartment. Even if the level of the two liquids be the same there is a tendency of the brine in the anode compartment to press through the diaphragm and flow into the kerosene. If the electric current be turned on the percolating brine becomes cathode liquid and carries caustic hydrate. The strength in caustic will increase according to the number of amperes which are sent through the cell. Furthermore, each drop of liquid as soon as it traverses the diaphragm runs through the perforations of the anode plate. acquires a globular shape, by a capillary phenomenon, produced on contact with the kerosene oil. This provokes a rapid separation of the aqueous liquid, so that every drop as soon as it forms detaches itself rapidly, sinks to the bottom of the oil and ac-
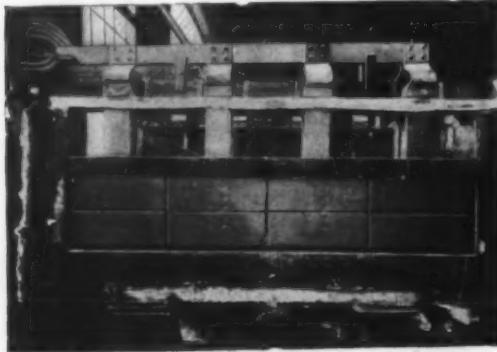
FIG. 3.—BODY OF CELL WITH SIDE PLATE REMOVED.

cumulates into a small caustic pocket (A). This puts it entirely outside of the zone of possible chemical or physical action. A goose-neck tube P drains this liquid from the supernatant oil, and thereby avoids its accumulation beyond desirable quantities. The inflow and overflow of the brine in the anode compartment are so regulated as to maintain a steady level. By a simple contrivance, which will be described hereafter, this level can be increased or decreased at will, thus controlling the hydrostatic pressure in the inside of the anode compartment. This gives a simple means of increasing the rate of percolation, and thereby producing stronger or weaker caustic liquor, in accordance with the density of the electric current.

That is, in short, the way this ingenious cell was conceived
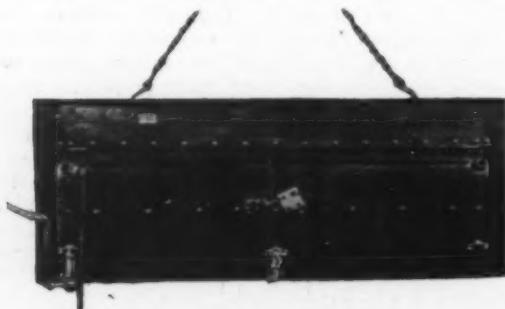
FIG. 4.—SIDE PLATE OF CELL.

by Mr. C. P. Townsend, in collaboration with Mr. Elmer A. Sperry, who contributed in a large measure to the engineering features of the apparatus."

Dr. Baekeland mentioned further that as soon as the cells were submitted to long practical tests many improvements sug-

gested themselves, and he found it advisable to change some of the mechanical features so as to make them better adapted to regular operation on a large scale. However, the original idea of the Townsend cell was respected.

Photographs were shown of the cells which had been in continuous operation since the beginning of 1906, in sets of 64 cells, each of them carrying from 2,000 to 2,300 amps. New cells are now under construction which will carry 4,000 amps. each. These cells are operated under an extraordinary heavy current density: about 1 amp. per square inch of anode surface.
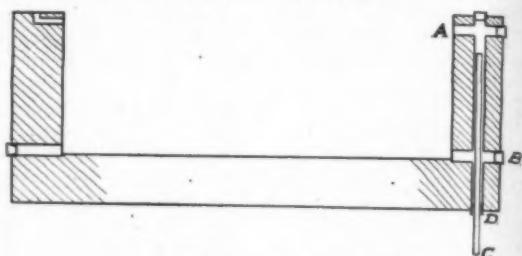

FIG. 5.—CHANNELS IN CELL BODY.

The cells measure about 8 feet long, 3 feet high and 12 inches wide (Fig. 2). They consist of a U-shaped non-conducting body, made of cement concrete (Fig. 3), against which are clamped two iron side plates (Fig. 4). bulging out in the middle and provided with flat borders; inside they carry a perforated cathode sheet, against which is applied the diaphragm—a description of which follows further. A rubber gasket enables the making of a tight fit when the side plates are clamped against the concrete body. For this purpose strong steel clamps hold the whole system rigidly together. Removing a few clamps enables the opening of the cell and the inspection of every part of it, and reassembling a cell requires but a very short time.

In order to maintain a steady level of the anode liquid the
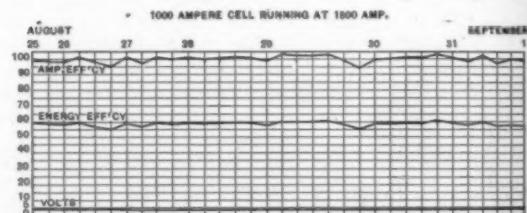

FIG. 6.—EFFICIENCY CURVES.

U-body is provided with a system of stoneware channels, which are imbedded in the cement concrete (Fig. 5). The upper cross channel (A) allows an exit for the gas, the lower (B) is intended as a flush-hole for cleaning the bottom of the cell. A glass tube (C) slides into the vertical channel through a perforated stopper (D). By moving this tube up and down a variable position can be given to the overflow, and, in this way the height of the liquid can be adjusted so as to control the hydrostatic pressure in the anode chamber. Merely changing the position of this glass tube produces, at will, a weak or strong caustic liquor. The overflowing brine is considerably weaker when it leaves the cell, and before it is fed anew it requires resaturation. How this is effected will be described later on.

A slight depression at the bottom of the iron side plates provides a caustic pocket where the cathode liquor accumulates, but the accumulated liquid never exceeds more than a few cubic centimeters, because it is steadily drained off by means of an adjustable iron pipe, which conveys the caustic liquor from underneath the kerosene—very much in the same way as the goose-neck tube of the classical Florentine flask. In this

manner the rich cathode liquor runs out both sides of the cell in two continuous, thin streams, which are collected in a funnel-like contrivance, from where the liquid is carried to pipe lines into the general caustic storage tank. From there it goes to the evaporating pans, where the remaining salt is
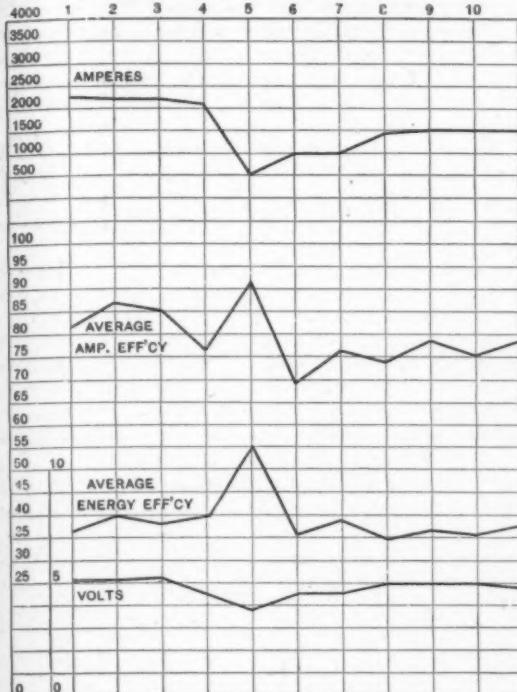

FIG. 7.—RELATION BETWEEN EFFICIENCY AND CURRENT DENSITY.

separated by concentration. Under these conditions the whole cell plant runs automatically and very little supervision is necessary.

There is a slight loss of kerosene, mainly due to evaporation and to mechanical waste, but the loss does not exceed a couple of dollars per day for a very large plant.

The whole construction of the cell is such that the initial

of asbestos paper, but this necessitated delicate handling, and the expense for renewals was quite considerable. During the last fourteen months the whole plant has been operated with diaphragms after Baekeland's patent. The latter consist of a woven sheet of asbestos cloth, of which the pores are filled with a special mixture of oxide of iron, asbestos fiber and colloid iron hydroxide. The latter material produces a sort of binder for the asbestos fiber and the oxide of iron; its function is somewhat similar to that of rosin or glue size in the manufacture of asbestos paper, but it has a great advantage over organic sizes, in that it does not become gummy in contact with

FIG. 9.—INSIDE VIEW.

sodium hydrate. The mixture is applied with a brush and painted on as ordinary paint. Whenever a diaphragm has to be renovated the surface is simply scrubbed and washed with water; a new coat of paint is applied, and after this is dry the diaphragm is again ready for use. This process has only to be repeated at long intervals, and requires but a few minutes. A diaphragm may not require repainting for several months.
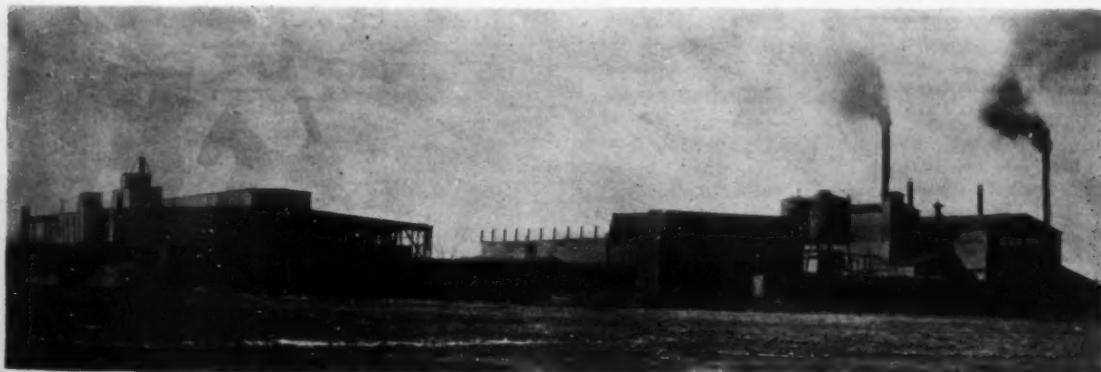

FIG. 8.—NIAGARA PLANT OF DEVELOPMENT & FUNDING CO.

cost is relatively very small. According to Dr. Baekeland the mercury alone of mercury cells represents several times the cost of a complete Townsend cell of the same capacity, which means, of course, a considerable economy in the initial cost of the plant, and also a lessening in the cost of amortization and maintenance.

The first diaphragms used in the Townsend cell were made

Even when impure or unsettled brine is used the painting has to be done only about once in five weeks.

If the cells are run with proper care the Acheson graphite anodes last astonishingly long. In some experiments where cells were operated with especial attention, corrosion was so slight that delicate scratches which had been made with the point of a needle on the surface of the anodes showed very

distinctly and with no alteration after several months of continuous operation. Even under the worst conditions the anodes only require partial renewal after about one year of continuous hard service.

Dr. Baekeland went on describing his patented system for resaturating spent anode liquor, a rather difficult problem of chemical engineering, if we take into consideration that the liquor, after it leaves the cells, shows Sp. Gr. 1.18, and has to be brought up rapidly to Sp. Gr. 1.2. The liquid is hot and carries uncomfortable amounts of chlorine gas, so that it cannot come in contact with any metal or other material which is attacked by chlorine. For a large plant hundreds of thousands of gallons of this liquid have to be resaturated and filtered daily. His system has been in continuous service for about sixteen months. For the description of the process we refer to United States patent No. 844,314.

. As to the efficiencies of the cells they are truly remarkable. In special tests (Fig. 6), where the cells were operated under very favorable conditions, it was possible to maintain an ampere efficiency quite close to 100 per cent, the voltage not exceeding 3.4 volts to 3.6 volts; but in practice these ideal conditions are seldom realized; where a large set of cells have to be operated at the same time their efficiency has often to be sacrificed to expediency. But even then ampere efficiencies ranging between 96 per cent and 97 per cent are not unusual under a load of about 1 amp. per square inch of anode surface. Under abnormally defective conditions, which were the result of some disturbance in the plant outside of the cell room, the ampere efficiency seldom dropped below 90 per cent during nearly a year and a half of operation.

It was pointed out how absurd it is to talk about ampere efficiencies or energy efficiencies of an electrolytic cell without mentioning the other factors, and especially without comparing current density. In order to illustrate this a curve was shown (Fig. 7) of some cells running under unusually poor efficiencies but under a load of 1 amp. per square inch. Reducing the load to about ¼ amp. per square inch (which even then is a current density higher than most known cells are run) it was possible to bring up the ampere efficiency to 93 per cent, the energy efficiency to 55 per cent, and to drop the voltage from 5 volts to 3.4 volts.

It has been pointed out that the strength of the caustic liquor produced in the Townsend cell can be regulated at will by increasing or decreasing percolation in conjunction with the strength of the current. By reducing percolation, cathode liquor containing 250 grams of NaOH per liter or more can be produced. In practice it is found advantageous to produce liquor containing about 150 grams of NaOH per liter. Such liquor carries also about 213 grams of salt. The latter is separated by evaporation from the caustic lye and is used over again.

The Niagara plant (Fig. 8) where the Townsend cell has been in continuous operation since the beginning of 1906, has been producing daily an average of 5 tons of caustic soda and 11 tons of high grade bleach. On the strength of what has been accomplished the plant is about to be increased to a fourfold capacity.

Society of Chemical Industry.—At the last meeting of the season of the New York Section of the Society of Chemical Industry, held at the Chemists' Club on May 24, Messrs. A. Hough and A. Moscovici presented a paper on the manufacture and properties of nitro-starch and the use of nitrogen pentoxide for the preparation of nitroglycerine and mannitol nitrate. Dr. Clifford Richardson spoke on improvements in modern asphalt pavements in Europe and America. Dr. Leo Baekeland presented a fully illustrated paper on the Townsend cell for the electrolytic manufacture of caustic soda and chlorine. This is very fully abstracted in the above article. A paper by Mr. W. R. Ingalls on the production and consumption of sulphuric acid was read by title.

Metallurgical Calculations.

By J. W. Richards, Ph. D.
Professor of Metallurgy in Lehigh University.
Roasting and Smelting Copper Ores.

The facts with regard to the metallurgy of copper may be found in condensed form, very clearly stated, in Schnabel's "Handbook of Metallurgy," Vol. I.; they may be found discussed at greater length in Dr. Peters' "Modern Copper Smelting" and "Principles of Copper Smelting," in Eissler's "Hydrometallurgy of Copper," and in Ulke's "Modern Electrolytic Copper Refining." In the present presentation it will be possible to merely enumerate the different processes concerned, the principles embodied in each and the methods of calculating quantitatively the nature of the reactions involved.

The chief ore of copper is chalcopyrite, $CuFeS_2$ which contains when pure approximately 30 per cent iron and 35 per cent each of copper and sulphur. It is most frequently found mixed with silica, SiO_2, as gangue, although various other gangue materials are sometimes present. This mineral is fusible, and if it were merely melted out of the enclosing rock, in an atmosphere which did not act upon it, it would merely lose one-fourth of its sulphur and melt to a fluid double sulphide of iron and copper, according to the following reaction:

$$2CuFeS_2 = Cu_2S \cdot 2FeS + S.$$

The melted sulphide of copper and iron resulting is called "matte," and, in fact, any mixture of Cu_2S and FeS in any proportions is called matte, and in practice may contain small quantities of PbS, ZnS, BaS, NiS, As, Sb, Te and even of Fe_3O_4, which is slightly soluble in these fused sulphides. In the majority of cases the matte is practically near enough to a mixture of Cu_2S and FeS to regard it as containing only those two substances.

Since the first operation in the extraction of copper from its usual sulphide ores is invariably the concentration to matte, we will first study the composition of this substance. Assuming matte to consist of Cu_2S and FeS in varying proportions, we may note that if it is all Cu_2S it contains $2 \times 63.6 = 127.2$ parts of copper to 32 parts of sulphur, or practically 4 copper to 1 sulphur, or is 80 per cent copper. For every 1.0 per cent of copper sulphide present there is, therefore, 0.8 per cent of copper in the matte; and, conversely, for every 1 per cent of copper in the matte there is 1.25 per cent of copper sulphide in it. The rest of the matte being iron sulphide, which contains 56 parts iron to 32 sulphur, it can be seen that the percentage of iron can be calculated for any per cent of copper; in fact, the per cent of copper fixes both that of iron and sulphur.

Illustration: A matte contains 40 per cent copper. How much iron and sulphur does it contain? How much copper sulphide and iron sulphide?

40 per cent copper $= 40 \times 5/4 = $ 50 per cent Cu_2S.
       $100 - 50 = 50$ "   FeS.
50 per cent FeS $= 50 \times 56/88 = 31.8$ "   Fe.
     $100 - (40 + 31.8) = 28.2$ "   S.

We may generalize this solution and say that if X represents the percentage of copper in a matte, that the composition of the matte is as follows:

Per cent of copper	$= X$
Per cent of Cu_2S	$= 1.25\ X$
Per cent of FeS	$= 100 - 1.25\ X$
Per cent of Fe $= (100 - 1.25\ X)\ 56/88 =$	$63.6 - 0.795\ X$
Per cent of S $= 100 - X - Fe$	$= 36.4 - 0.205\ X$

Similarly, if Y represents the percentage of iron in a matte its composition is:

Per cent of Fe	$= Y$
Per cent of FeS	$= 1.57\ Y$
Per cent of Cu_2S	$= 100 - 1.57\ Y$
Per cent of Cu	$= 80 - 1.26\ Y$
Per cent of S	$= 20 + 0.26\ Y$

Finally, if Z represents the percentage of sulphur in a matte its composition is:

Per cent of S	$= Z$
Per cent of Fe	$= 3.89\ Z - 77.8$
Per cent of Cu	$= 177.8 - 4.89\ Z$
Per cent of FeS	$= 6.11\ Z - 122.3$
Per cent of Cu²S	$= 222.3 - 6.11\ Z$

The following tables may be then drawn up, and will be found useful for reference:

Percentages.

Cu.	Fe.	S.	Cu²S.	FeS.
80	0.0	20.0	100.0	0.0
75	4.0	21.0	93.8	6.2
70	8.0	22.0	87.5	12.5
65	12.0	23.0	81.3	18.7
60	15.9	24.1	75.0	25.0
55	19.9	25.1	68.8	31.2
50	23.9	26.1	62.5	37.5
45	27.9	27.1	56.3	43.7
40	31.8	28.2	50.0	50.0
35	35.8	29.2	43.8	56.2
30	39.8	30.2	37.5	62.5
25	43.8	31.2	31.3	68.7
20	47.7	32.3	25.0	75.0
15	51.7	33.3	18.8	81.2
10	55.7	34.3	12.5	87.5
5	59.7	35.3	6.3	93.7
0	63.6	36.4	0.0	100.0

For regular use in a smelting works it is easy to calculate out a table similar to the above for every 1 per cent of copper, and keep it under a glass cover for constant reference. Or, if preferred, a large piece of cross-section paper can be taken, and a diagram prepared with the percentages of copper as abscissas, from 0 to 80, and with ordinates running up to 100. A line drawn from an ordinate 36.4 at abscissa 0 to ordinate 20 on abscissa 80, will represent the sulphur content; a line from ordinate 63.6 on abscissa 0 to ordinate 0 on abscissa 80, will represent the iron content; a line from 0 to ordinate 100 on abscissa 80 will represent the Cu²S content; and a line from ordinate 100 on abscissa 0 to ordinate 0 on abscissa 80 will represent FeS content.

It has been already shown that if a chalcopyrite ore were smelted down, as in a shaft furnace, to a matte, that about a 35 per cent matte is as rich as could be made by simple fusion. In fact, a much poorer matte would usually result, because chalcopyrite is often accompanied by pyrite, FeS², and which on simple heating becomes FeS, and thus dilutes the matte still further.

Illustration: A chalcopyrite copper ore contains 30 per cent by weight of chalcopyrite and 25 per cent of iron pyrites. What grade of matte would result from a simple fusion of this ore, without roasting, in a reducing atmosphere? Thirty per cent CuFeS² contains:

$30 \times 160 \div 336$	$= 13$ per cent Cu²S.
$30 \times 176 \div 336$	$= 14$ " FeS.

25 per cent of FeS² will produce

$25 \times 88 \div 120$	$= 18$ " FeS.
Total matte $= 45$	" of the ore.

Composition of matte:

Cu²S = 29 per cent = 23 per cent copper.
FeS = 71 "

It is thus seen that the presence of iron pyrites in the ore tends to lower the grade of the matte produced.

The essential principle of the metallurgy of copper is now before us. It is this fact: that if some of the sulphur in the ore be first removed by roasting, and this operation be followed by smelting, the copper will first take enough of the sulphur to form Cu²S, and then what sulphur is left over will form FeS. The amount of FeS which will accompany the Cu²S into the matte is entirely a question of how much sulphur is left to combine with iron after all the copper has been satisfied, and this amount of sulphur can be exactly controlled by the preliminary roasting.

Illustration: Taking the ore mentioned in the previous illustration, containing 30 per cent of chalcopyrite (= 10.4 per cent of copper) and 25 per cent of iron pyrites, what per cent of sulphur does it contain, and what would be the quality of the matte produce by fusion in a reducing atmosphere if the sulphur were previously roasted down to ½ or ¼ or ⅛ of its original amount?

Sulphur in 30 per cent chalcopyrite:

$30 \times 128 \div 368$ = 10.5 per cent.

Sulphur in 25 per cent pyrites:

$25 \times 64 \div 120$ = 13.3 "

Total = 23.8 "

If the sulphur were reduced to ½, ¼ or ⅛ its original amount there would remain, out of the 23.8 per cent, either 11.9, 5.95 or 2.97 parts of sulphur per 100 of original ore; i. e., per 10.4 parts of copper. The 10.4 of copper requires 2.6 of sulphur to form Cu²S, leaving the following amounts of sulphur in excess to form FeS:

Sulphur left in ore............	11.90	5.95	2.97
Sulphur needed for Cu²S.....	2.60	2.60	2.60
Sulphur left to form FeS......	9.30	3.35	0.37
FeS which will be formed.....	14.61	5.26	0.58
Cu²S formed	13.00	13.00	13.00
Matte formed	27.61	18.26	13.58
Per cent of Cu in matte......	37.7	57.0	76.6

It is thus evident that the degree of the previous roasting determines absolutely the quality or grade of the matte formed on the subsequent smelting.

It can be readily seen that since partial roasting virtually oxidizes a portion or fraction of the ore, that it is the practical equivalent of roasting if we can get oxide ore to mix with sulphide ore. The raw oxide ore acts exactly as so much roasted ore, and thus enriches the matte on subsequent smelting.

Illustration: What proportion of a cuprite (copper oxide) ore, free from sulphur and containing 28 per cent of copper, can be mixed with the chalcopyrite ore of the previous illustrations, to produce a matte on subsequent reducing smelting containing 50 per cent of copper?

One hundred parts of the chalcopyrite ore contains 10.4 parts Cu, 20.8 parts Fe, 23.8 parts S.

The sulphur, however, is not all available for making matte, because one-fourth of the sulphur in chalcopyrite and one-half that in pyrite is given off by simple heating. There would be lost, therefore, and not available for matte, sulphur as follows:

S in chalcopyrite 10.5 × ¼ = 2.6 not available.
S in pyrite 13.3 × ½ = 6.7 " "

9.3 " "

Available sulphur = 23.8 − 9.3 = 14.5 parts per 100 of ore. In a 50 per cent matte there is (see previous table) 26.1 per cent of sulphur; 14.5 parts of sulphur available for matte is therefore capable of producing 14.5 ÷ 0.261 = 55.5 parts of 50 per cent matte, which would contain 27.75 parts of copper. But there is only 10.4 of copper in the chalcopyrite ore, leaving therefore 16.35 of copper to be supplied by the cuprite ore, and therefore capable of taking up 16.35 ÷ 0.28 = 58 parts of the oxide ore per 100 of the sulphide ore. A mixture of 100 of the sulphide ore and 58 parts of the oxide ore would therefore smelt down in a reducing atmosphere to a 50 per cent matte.

We have carefully specified a reducing atmosphere as the condition for smelting down to produce the calculated results, because under these conditions the oxygen of the roasted ore or of the raw oxide ore added cannot combine with the sulphur of the ore and go off as SO^2, but is taken up by the carbon or CO in the smelting furnace. In smelting in a shaft furnace with carbon as fuel these conditions exist, and the sulphur in the charge can be counted on as practically all forming matte. If the smelting is done in a reverberatory furnace, with a neutral atmosphere, much sulphur will be removed from the charge by the oxygen of the roasted ore or of the raw ore added, and a richer matte results. The reactions of this elimination of sulphur are mostly

$$Cu^2S + 2CuO = 4Cu + SO^2$$
$$Cu^2S + 2Cu^2O = 6Cu + SO^2$$
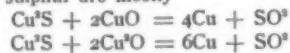
On an average, a matte 10 per cent richer in copper will be obtained from a given roasted ore by smelting it down in a reverberatory furnace, where these reactions between sulphide and oxide of copper can occur, than in shaft furnace smelting with coke, in which the oxygen of the charge is taken up by the carbon.

There is a third variety of smelting which is in reality a combined roasting and smelting-down operation. We refer to what is called pyritic smelting, where a sulphide ore is roasted in a blast of air so rapidly that the heat generated melts down the charge and produces a concentrated matte. This operation is done on pure sulphides, however, without preliminary roasting, and will be subsequently treated by itself.

The Roasting Operation.

When an ore is roasted it loses some sulphur and takes up oxygen. The roasted ore will therefore have a different weight from the unroasted ore. Thus:

100 parts of Cu^2S become	90.0 parts of Cu^2O.
100 parts of Cu^2S become	100.0 " CuO.
100 parts of Cu^2S become	{ 100.0 " $CuSO^4$.
	{ 50.0 " CuO.
100 parts of FeS^2 become	64.4 " Fe^3O^4.
100 parts of FeS^2 become	125.0 " $FeSO^4$.

Problem 101.

A pyritous copper ore from Ely, Vt. (see Peter's "Modern Copper Smelting," p. 133), contained before and after roasting, in percentages:

	Before.	After.
Sulphur	32.6	7.4
Copper	8.2	9.1

The condition of the copper in the roasted sample was determined as

	Per Cent.
Copper as $CuSO^4$	1.3
Copper as CuO	2.1
Copper as Cu^2S	5.7

Required:

(1) The weight of roasted ore per 100 of raw ore.

(2) The proportion of the sulphur removed by roasting.

(3) The grade of matte which would be formed by smelting down in a reducing atmosphere in a shaft furnace.

(4) The grade of matte which would be formed by smelting down in a neutral atmosphere in a reverberatory furnace.

Solution:

(1) Since no copper is lost, there will be produced per 100 of raw ore:

$$100 \times \frac{8.2}{9.1} = 90.1 \text{ of roasted ore.} \quad (2)$$

	Parts.
(2) Sulphur in 100 of raw ore	= 32.6
Sulphur in 90.1 of roasted ore = $90.1 \times 0.07 \times 4$	= 6.7
Sulphur eliminated	= 25.9

Proportion removed:

$$\frac{25.9}{32.6} = 0.793 = 79.3 \text{ per cent.} \quad (2)$$

(3) Per 100 of roasted ore we have:

	Kg.
Sulphur to form $Cu^2S = 9.1 \times 0.25$	= 2.3
Sulphur to form FeS = 7.4 − 2.3	= 5.1
FeS formed = $5.1 \times 88/32$	= 14.0
Cu^2S	= 11.4
Matte formed	= 25.4

$$\text{Per cent of copper} = \frac{9.1}{25.4} = 0.358 = 35.8 \text{ per cent.} \quad (3)$$

(4) In

$$CuSO^4 + Cu^2S = 3Cu + 2SO^2$$
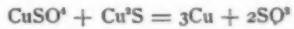
every 1 part of copper as $CuSO^4$ reduces two parts of copper as Cu^2S, and causes the elimination as gas of 1 part of sulphur. In

$$2CuO + Cu^2S = 4Cu + SO^2$$
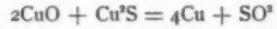
1 part of copper as CuO reduces 1 part of copper as Cu^2S, and causes the elimination of one-fourth its weight of sulphur. Therefore, the sulphur eliminated by the reactions given is:

	Parts.
By reaction of sulphate on sulphide 1.3×1	= 1.3
By reaction of oxide on sulphide $2.1 \times \frac{1}{4}$	= 0.5
Total =	1.8
Sulphur remaining to form matte = 7.4 − 1.8 =	5.6
Sulphur needed to form Cu^2S	= 2.3
Sulphur left to form FeS = 5.6 − 2.3	= 3.3
FeS formed = $3.3 \times 88/32$	= 9.1
Cu^2S formed	= 11.4
Matte formed	= 20.5

$$\text{Per cent of copper} = \frac{9.1}{20.5} = 0.444 = 44.4 \text{ per cent.} \quad (4)$$

In the roasting of ores a large amount of heat is set free, since both the sulphur and the metal are usually oxidized.

Problem 102.

In the ore of Problem 101, taking the data given for its weight before and after roasting, how much heat was generated in its roasting per kilogram of ore treated?

Solution: Starting with 100 parts of original ore it contained 32.6 parts of sulphur and 8.2 of copper. The latter corresponds to 2.05 of sulphur as Cu^2S, which would mean 8.2 of sulphur altogether as chalcopyrite, leaving 24.4 of sulphur present in the ore as iron pyrites.

In 100 of the roasted ore we have 5.7 parts of copper as Cu^2S, therefore unchanged, 2.1 parts changed to CuO and 1.3 parts changed to $CuSO^4$. These contain sulphur as follows:

	Parts.
Sulphur for 5.7 Cu as Cu^2S	= 1.4
Sulphur for 1.3 Cu as $CuSO^4$	= 0.7
Sulphur for copper compounds	= 2.1
Sulphur for FeS = 7.4 − 2.1	= 5.3
FeS = $5.3 \times 88/32$	= 14.6

Per 90.1 of roasted ore there is present:

Cu as $CuSO^4$	= 1.17
Cu as Cu^2S	= 5.14
Cu as CuO	= 1.89
Fe as FeS = $9.3 \times .901$	= 8.38
Sulphur	= 6.67

We therefore have:

Heat to Decompose Raw Ore.

			Calories.
8.20 Cu as Cu^2S	= 8.20 ×	160 =	1,312
18.85 Fe as sulphide	= 18.85 ×	429 =	8,087
		Sum =	9,399

Heat of Formation of Products.

5.14 Cu as Cu^2S	= 5.14 ×	160 =	862
1.17 Cu as $CuSO^4$	= 1.17 ×	2,857 =	3,343
1.89 Cu as CuO	= 1.89 ×	593 =	1,121
25.93 S to SO^2	= 25.93 ×	2,164 =	56,112
9.55 Fe to Fe^3O^4	= 9.55 ×	1,612 =	15,395
9.30 Fe to FeS	= 9.30 ×	429 =	3,990
		Sum =	80,783

Net heat evolved = 80,783 — 9,399 = 71,384 Calories.
Per 1 kg. of ore   =   713   "

In the roasting of copper ore the heat generated by the oxidation of the ore is an important item in the heat required by the furnace. In the above case, for instance, each kilogram of ore developed about one-tenth as much heat as a kilogram of coke, and with proper arrangements for conserving heat, such as thick walls and compact shape of furnace, combined with regeneration of heat from the cooling ore, there is no reason why such an ore should not be made to roast itself. Such a scheme, when practicable, is highly economical in districts where fuel is dear. A long-bedded calciner, with its single hearth and large radiating surface, cannot meet these conditions, but furnaces having superposed hearths and arrangements for discharging cold ore, cooled by the incoming air, such as the Spence and MacDougal furnaces, can work on many ores without using other fuel.

Problem 103.

An improved Spence furnace used at Butte, Mont., calcines 90,000 pounds of concentrates in 24 hours, of the following composition:

	Per Cent.
Copper	9.8
Iron	33.8
Silica	13.3
Sulphur	41.2

Four-fifths of the sulphur is removed, and the roasted ore is practically discharged cold; 1,500 pounds of slack coal, calorific power 6,500, is used per day. The furnace gases contain:

	Per Cent.
CO^2	0.6
SO^2	7.2
H^2O	0.6
N^2	81.3
O^2	10.3
	100.0

and escape into the chimney at 200° C. Ore charged and discharged cold. Furnace has an outside radiating surface of 5,000 square feet.

Required:

(1) The heat balance sheet of the furnace.

(2) The proportion of the heat generated by the roasting of the ore and by the combustion of fuel.

(3) The heat radiated and conducted to the air per square foot of outside surface per minute.

Solution:

(1) Per 100 of ore used the unroasted and roasted ore will contain, respectively:

Copper	9.8	9.8
Iron	33.8	33.8
Silica	13.3	13.3
Sulphur	41.2	8.2

Assuming that the copper remains in the roasted ore, two-thirds as Cu^2S, one-quarter as CuO and one-tenth as $CuSO^4$, while the iron takes the rest of the sulphur to form FeS, the excess of iron forming half Fe^2O^3 and half Fe^3O^4. We have the composition of the roasted ore as:

Cu^2S	8.2
CuO	3.1
$CuSO^4$	2.0
FeS	17.0
Fe^2O^3	16.4
Fe^3O^4	15.9
SiO^2	13.3
	75.9

The copper and iron existed in the unroasted ore virtually as Cu^2S, FeS and FeS^2, and therefore the 8.2 of Cu^2S and the 17.0 of FeS in the roasted ore can be considered as unchanged. The actual change in the roasting has been the formation of 3.1 CuO and 2.0 $CuSO^4$ from Cu^2S, and the formation of 16.4 Fe^2O^3 and 15.9 Fe^3O^4 from FeS. If we, therefore, subtract from the heat of formation of these amounts of CuO, $CuSO^4$, Fe^2O^3 and Fe^3O^4, and the SO^2 formed, the heat required to resolve the Cu^2S, FeS and FeS^2 into their constituents, we shall get the net heat evolution in the roasting process. The heats of formation involved are:

Molecular Heat.

(Cu^2, S)	=	20,300 Calories =	127	Cal. per kg. of product.			
(Cu, O)	=	37,700 "	=	471 "	"	"	"
(Cu, S, O^4)	=	181,700 "	=	1,136 "	"	"	"
(Fe, S)	=	24,000 "	=	273 "	"	"	"
(Fe^2, O^3)	=	195,600 "	=	1,223 "	"	"	"
(Fe^3, O^4)	=	270,800 "	=	1,167 "	"	"	"
(S, O^2)	=	69,260 "	=	1,082 "	"	"	"

We then have the heat evolved and absorbed as follows:

Evolved.

			Calories.
Formation of CuO	3.1 ×	471 =	1,460
Formation of $CuSO^4$	2.0 ×	1,136 =	2,272
Formation of Fe^2O^3	16.4 ×	1,223 =	20,057
Formation of Fe^3O^4	15.9 ×	1,167 =	18,555
Formation of SO^2	66.0 ×	1,082 =	71,412
		Total =	113,756

Absorbed.

Decomposition of Cu^2S	4.1 ×	127 =	521
Decomposition of FeS	36.1 ×	273 =	9,855
		Sum =	10,376

Net heat evolution per 100 of concentrates:

113,756 — 10,376 = 103,380 Calories.

The gases contain 33 pounds of sulphur for every 100 of ore roasted, and the analysis shows there is 0.072 cubic foot of SO^2 in each cubic foot of chimney gas. This weighs 0.072 × 2.88 = 0.2074 ounces, and contains just half its weight = 0.1037 ounces = 0.00674 pounds of sulphur. There is therefore produced, per 100 pounds of ore, 33 ÷ 0.00674 = 4,896 cubic feet chimney gas.

This contains, from its analysis:

CO^2	29
SO^2	353
H^2O	29
O^2	504
N^2	3,981

And at 200° C. carries heat up the chimney as follows:

$S_m (0 - 200°)$

CO_2	$29 \times 0.414 =$	12 oz. cal. per 1°.		
SO_2	$353 \times 0.420 =$	148	"	"
H_2O	$29 \times 0.370 =$	11	"	"
O_2 N_2	$4.485 \times 0.308 =$	1,381	"	"

$$Sum = 1,552 \text{ " "}$$
$$= 97 \text{ lb. Cal. per } 1°.$$
$$= 19,400 \text{ lb. Cal. per } 200°.$$

The fuel evolves $6,500 \times 1,500 = 9,750,000$ pounds Calories per day $= 10,830$ pounds Calories per 100 of ore roasted.

(1)   BALANCE SHEET PER 100 OF ORE ROASTED.   (1)

	Lb. Calories.
Evolved by the fuel......................	10,830
Evolved by the roasting operation........	103,380
Sum	114,210
Loss in chimney gases...................	19,400
Loss by radiation and conduction.........	94,810
Sum	114,210

(2) The proportion of the total heat generated by the ore itself is:

$$\frac{103,380}{114,210} = 0.90 = 90 \text{ per cent.}$$

by the fuel   10   "   (2)

The heat lost by radiation and conduction per day is:

	Lb. Calories
$94,810 \times 900$	$= 85,329,000$
Per minute	$= 59.000$
Loss per square foot of surface, per minute $\dfrac{59,000}{5,000} =$	11.8 (3)

Problem 104.

The Evans-Klepetko cylindrical roaster used at Butte, Mont., is 19 feet high, 18 feet in diameter, and roasts 80,000 pounds of concentrates daily from 35 per cent sulphur down to 7 per cent (Dr. Peters). The evolution of heat in the roasting operation is sufficient to supply all the heat needed. The stirrer arms are cooled by water circulation, 100 pounds of water being used per minute, and raised in temperature 50° C. Assume the evolution of heat to be 90 per cent as great as in the roasting of ore in Problem 103, and the chimney loss to be correspondingly smaller.

Required:

(1) The heat balance sheet per 100 of ore roasted.

(2) The loss by radiation and conduction per square foot of outside surface of the furnace.

Solution:

(1)   *Heat Evolved.*

	Lb. Calories,
90 per cent of 103,380	$= 93,040$

Heat Distribution.

Heat in chimney gases	$= 17,460$
Heat in cooling water	$= 9,000$
Heat lost by radiation and conduction	$= 66,580$
Sum $=$	93,040 (1)

(2) The outside surface consists of the top and bottom and sides. Their area is as follows:

	Sq. Feet.
Sides $18 \times 3.14 \times 19$	$= 1,074$
Bottom $18 \times 18 \times 0.78$	$= 253$
Top	$= 253$
Total $=$	1,580

Loss by radiation and conduction

		Lb. Calories.
Per 100 of ore	$=$	66,580
Per day	$=$	53,264,000
Per minute	$=$	37,000
Per square foot surface per minute $\dfrac{37,000}{1,580} =$	$=$	23.4 (2)

It is interesting to note, as comparing this compact cylindrical furnace with the rectangular furnace of Problem 103, that although no fuel is used and cooling water is used, and radiation losses per square foot are greater because of thinner walls, yet the much smaller radiating surface more than counter-balanced these considerations, and permitted the furnace to run more economically.

Thick walls and minimum radiating surface are the requisites for economy of fuel in general, and the *sina qua non* for roasting copper sulphide ores by their own self-generated heat of oxidation.

Foundrymen's Convention.

At the convention of the American Foundrymen's Association, held in Philadelphia on May 21, 22 and 23, all records as to attendance were broken, since the number of those who registered was almost 1,400. Two notable features of the convention were the formation of the American Brass Founders' Association and the tribute paid by the foundrymen to their indefatigable secretary, Dr. Richard Moldenke, to whom they presented as a tangible expression of their admiration a silver punch bowl and a purse containing $1,200 in gold. The new president is Mr. Stanley G. Flagg, Jr., of Philadelphia.

On account of the great extent which the exhibits of foundry machinery and supplies had assumed—there being some seventy firms represented instead of forty at the last meeting—the convention was held in the Armory of the Second Regiment. Some of the most notable exhibits were the following: Universal molding machines, by Ph. Bonvillain and E. Roceray, of Paris; various applications of the thermit process and the production of pure metals free from carbon by the aluminothermic method, by the Goldschmidt Thermit Co., of New York (who distributed as a souvenir very pretty gold-plated scarf pins in form of their trademark, showing a thermit welding outfit); brazing apparatus of the American Ferrofix Brazing Co., of Philadelphia; melting furnaces of the Hawley Down Draft Furnace Co., of Chicago; the Monarch Engineering & Manufacturing Co., of Baltimore, and the Rockwell Engineering Co., of New York; industrial railway and accessories, by the Arthur Koppel Co., of New York; pressure blowers and fans by the B. F. Sturtevant Co., of Boston; pyrometers, by Edward Brown & Son, of Philadelphia; ferros and other alloys, by the Primos Chemical Co., of Primos, Pa.; conveying machinery, by the Link-Belt Co., of Philadelphia; graphite crucibles, by the Joseph Dixon Co., of Jersey City, and by R. B. Seidel, of Philadelphia; foundry supplies by the S. Obermayer Co., of Cincinnati, and the Whiting Foundry Co., of Harvey, Ill.; foundry ladles, cranes, furnaces and sundry foundry supplies, by the Northern Engineering Works, Detroit; by the New England Engineering & Equipment Co., Boston; by the J. W. Paxson Co., of Philadelphia; by the J. D. Smith Foundry Supply Co., of Cleveland, and the E. H. Mumford Co., of Philadelphia; ferro-alloys and refractories, by the Western Foundry Supply Co., of East St. Louis, Mo.; firebrick by Cyrus Borgner Co., of Philadelphia; graphites, sands and gravels, by Pettinos Bros., Bethlehem, Pa.; gluetrin core binder, by Robeson Process Co., of Camden, N. J., etc.

Abstracts of the papers presented at the convention will be given in our Synopsis after publication.

PHILADELPHIA MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The sixth annual and eleventh general meeting of the American Electrochemical Society was called to order on Thursday, May 2, by President Carl Hering in the large lecture hall of the John Harrison Laboratory of Chemistry of the University of Pennsylvania.

Dr. EDGAR F. SMITH, the distinguished professor of chemistry at the University of Pennsylvania, referred, in his speech of welcome, to the fact that the first and second chemical societies of this country were founded in Philadelphia in connection with the University in 1792 and 1812. Again, the youngest chemical society, the American Electrochemical Society, held its inaugural meeting at the University in 1902. But the University has also held very close relations to electrochemistry through its professors. Dr. Smith referred to the early important work done by Robert Hare in electrochemistry and also to the long series of recent researches carried out under his own direction on electro-analysis.

Mr. CARL HERING, as president, thanked Dr. Smith and the University for the courteous welcome and hospitality.

Then followed the business meeting of the Society.

The annual reports of the board of directors, of the secretary and of the treasurer were presented. The financial status of the Society during the year 1906 was satisfactory in that the expenditures were brought within the receipts which, unfortunately, was not the case in 1905. On Dec. 31, 1906, there was a cash balance on hand of over $300.

The report of the tellers of the annual election was then read.

Prof. Charles F. Burgess, of the University of Wisconsin, is the new president; Prof. J. W. Richards, of Lehigh University, Bethlehem, Pa., is the new secretary, while Mr. P. G. Salom, of Philadelphia, Pa., was re-elected treasurer.

Messrs. C. E. Acker, Alfred H. Cowles and W. H. Walker were elected vice-presidents, Messrs. E. F. Roeber, S. S. Sadtler and L. Kahlenberg were elected managers.

PRESIDENTIAL ADDRESS.

Mr. CARL HERING then presented his presidential address, which dealt with the American Electrochemical Society itself, its past, present and particularly its future. He pointed out that modern societies are usually conducted by a few of their members—the chosen board of directors. Although it is impossible for a few to always please everybody, the history of the American Electrochemical Society has been free from any serious dissentions or factions.

Mr. Hering gave an outline of the work of the Society during the past five years. His account was illustrated by some interesting curves showing the fluctuations of attendance at meetings, size of volumes of transactions, number of papers presented at different meetings, growth of membership and finances. In general, the trend of the curves is toward the normal, showing that the wide fluctuations that are to be expected when a new society is started are lessening and things are apparently beginning to assume their natural levels. The three comparative curves in Fig. 1 show the growth of the

older Bunsen Society in Germany of the American Electrochemical Society and of the younger Faraday Society in Great Britain. It will be seen that the American Electrochemical Society has grown more rapidly than either of the others and is nearly as large as its older sister society. Whether these rates will continue is mere conjecture, but if they do, our Society will, in the near future, be the largest of them all.

Dividing the annual expenditures by the number of members shows that what the Society has done for its members for the last five years has cost it $6.05 per member per year, and for this each member has paid only $5.00 dues. This apparent paradox is explained in part by the fact that the initiation fees have been used to pay part of the expenses—which is not good financiering—and partly by the fact that the Society has another source of income, namely, the sale of back numbers of *Transactions*. Nevertheless, the question of raising the dues has come up, but Mr. Hering thinks that if the management continues to exercise strict economy there is no immediate necessity to raise the dues.

The question has also been brought up of abandoning one meeting a year. But Mr. Hering advocates a mean between the plan of one meeting and the plan of two meetings. He proposes to let the large Spring meeting be the important one, and then hold a less pretentious and perhaps shorter meeting in the Fall in a central location like New York City, where there is a large local section and a large local membership. The last Autumn meeting in New York City was intended to be a test of this plan, but unfortunately it was encumbered by a number of mishaps which do not represent normal conditions.

CHARLES F. BURGESS,
President American Electrochemical Society.

The plan will, therefore, be tried again next Autumn, when another meeting will be held in New York City, and the large and active New York local section will assume the responsibility of its success. To omit one meeting entirely would, in Mr. Hering's opinion, be the beginning of the decadence of the Society, resulting ultimately in its absorption by some larger Society. By far the greater number of the members have joined for the sake of the *Transactions,* and many of these would, no doubt, be unwilling to pay the dues for only one volume. The *Transactions* are one of the chief attractions and assets of the Society and they should be guarded zealously.

The last part of the presidential address dealt with a proposition which seems of very considerable importance. It has been brought up recently in the form of a tentative proposition from the American Chemical Society, and originated by Dr. W. A. Noyes. Briefly stated, the two basic features of the proposition are, first, to combine into one monthly publication all papers on physical chemistry and electrochemistry read before either society, and, second, to reduce the cost of the publications of both societies by having the work done by one publication board. It is proposed, also, to combine the *Journal of Physical Chemistry* with this new joint publication.

Mr. Hering considers it needless to say that such a co-operation would be of great benefit to all concerned and is highly desirable. To have the work of publishing done by one board for both societies would naturally reduce the expenses

of both, as it avoids the duplication of expenses, gives both the advantages of cheaper rates and involves the principle that the cost of an additional amount of work is generally less in proportion. It therefore seems hardly necessary to dwell on the self-evident advantages of this feature, especially in the present era in which the combination of joint interests to reduce expenses is the prevailing practice.

The advantages of combining into one publication all papers on these two almost inseparable subjects, which are read before either society, and at the same time combining with it the *Journal of Physical Chemistry,* are also so self-evident that it seems hardly necessary to call attention to them. It is estimated that the amount of matter in it would probably be about double that of the American Electrochemical Society's *Transactions.* Not only would such a publication be of more value to those who get it than any of its constituents would be; not only would it bring together all the papers on the same general subject under one cover, but it would also avoid the duplication of the same paper in the different publications, it would give each paper a wider circulation, and would, in the future, facilitate the searches for published information on this general subject and making references thereto.

Mr. Hering thinks that if such a proposition is carried out it must be equitable to all concerned, neither party receiving any advantages at the expense of the other, and neither party assuming risks which the other should share. To be permanent the divisions of expenses for the future should not be based on present conditions. The individuality and the independence of the two societies should not be affected by such a joint publication of their papers.

FIG. I.—GROWTH OF ELECTROCHEMICAL SOCIETIES IN GERMANY, UNITED STATES AND ENGLAND.

Mr. Hering outlined a method of dividing the expenses between the two societies. The almost certain loss of some members who now belong to both societies is, in his opinion, the only feature on the other side of the balance sheet. There are now about 200 who belong to this class. This loss may perhaps be divided between the two societies but it is likely to fall almost entirely on the American Electrochemical Society.

In summing up his discussion of the proposition, Mr. Hering concluded "that such a combination of publications is of mutual advantage, is very desirable and should be accomplished if possible; that if entered into, it should be done with the view of permanency and not as an experiment, and that, therefore, the arrangements should be such that they will be as equitable in the future under changed conditions as they are to-day; that we should not thereby lose our independence or subject our papers to the censorship of any other society; and that it should not jeopardize the future existence of this society."

Contrary to ordinary practice, Mr. Hering's presidential address was open for discussion, which dealt with the proposed joining of publications.

Dr. Wilder D. Bancroft said that he agreed with Mr. Hering what ought to be done but not how it ought to be done. Mr. Hering's elaborate plan of dividing the expenses between the two societies would not work in practice, and he favored the other plan proposed by the American Chemical Society, that the American Electrochemical Society pay for each of its members a lump sum of $3.00 a year over to the Chemical Society, and let them do the work. He thought this plan was more convenient and perfectly safe. He thought the whole

proposition an ideal one, since everybody would gain and nobody lose.

However, the sentiment of the members was by no means unanimous concerning the last point, as became evident from the remarks of some of the other speakers. Mr. Alois von Isakovics, the secretary of the New York Section of the Society, said that if the proposition went through we would certainly lose members. If the independence of the *Transactions* would be lost the Society itself would lose its individuality.

The new-elected president, Prof. Charles F. Burgess, spoke in the same sense. He expressed grave doubts whether the engineers—which are a large proportion of the membership of the American Electrochemical Society—would like such an arrangement. He thought such a step might seriously impair the usefulness and existence of the Society.

Mr. Charles J. Reed emphasized that no action on this important matter should be taken by the board of directors. The board of directors has the right to make definite arrangements only for one year and the Society at large must have the last word. If the two sub-committees appointed by the boards of directors of the two societies to consider the question should be able to agree on some plan, this plan to become effective should first be put to a mail vote so that all members of the Society may express their opinion. Mr. Sperry spoke in the same sense and a motion to that effect was carried.

SOME CONSIDERATIONS ON THE EFFICIENCY OF ELECTROLYTIC CELLS.

A paper on this subject was presented by Mr. W. R. Mott, who discussed the matter with the aid of various diagrams. Mr. Mott emphasized that the energy efficiency (watt-hour efficiency) is in most cases of practice more important than the current efficiency (ampere-hour efficiency). In the first case considered by the author the relation between voltage and current density (or current, since the dimensions of the cell are given) is represented by a straight line. In the second case the desired reaction does not start at low current densities, but only after the latter has reached a certain value; this is indicated by a sharp bent in the volt-ampere curve at that point. The third case considered by the author is like the second, but when the current density is further raised another new and undesirable reaction sets in; this is indicated by a second bent in the volt-ampere curve. In such a case it is necessary to work within the limits indicated by the two bents of the curve. For all three cases the watt-hour efficiency and ampere-hour efficiency curves were given, corresponding to the volt-ampere curves. Mr. Mott also pleaded for expressing the rate of chemical corrosion in terms of current density. His argument in this respect was as follows: He considered the deposition of a metal by electrolysis, and first assumed that nothing happens except the desired metal deposition. Then we have an ampere-hour efficiency of 100 per cent according to Faraday's law. But this is hardly ever obtained in practice, and Mr. Mott took into consideration one loss, namely, the redissolving of some of the deposited metal by purely chemical action. He also assumed that this chemical waste or corrosion is constant and independent of the current density. In this case the current consumed may be c, but part of it a is wasted, because the deposit corresponding to a, according to Faraday's law, is redissolved. Hence, only $c-a$ represents the useful current and the ratio of $c-a$ to c is the efficiency. In reality c and a were not considered as current by Mr. Mott, but as current density, and therefore given in amperes per unit area of active electrode. Just as the corrosion a in this case, Mr. Mott proposed to state any chemical corrosion in terms of current density.

The paper was briefly discussed by Dr. J. W. Richards.

CHANGES OF CONCENTRATION AND MIGRATION VELOCITIES.

A paper on this subject was presented by Mr. C. J. Reed. He attacked the statement that changes in concentration can be
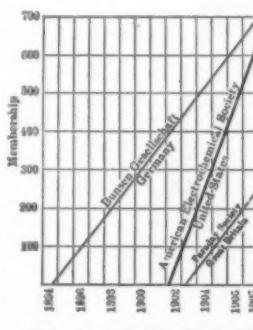
caused by unequal migration velocities of oppositely charged ions. In his argument he assumes a cell with an electrode at each end and then considers any two arbitrary fixed planes within the electrolyte filling its whole cross-section. He shows that the space between these two arbitrary planes will always contain the same number of ions as at start, since the passage of both kinds of ions is the same through the two planes; hence the concentration in the space between these planes will remain constant. "Furthermore, it follows that since no changes in concentration could be produced in the body of an electrolyte by the inequality in the constant velocities of the oppositely moving ions, there would be as a result of such inequality accumulations of oppositely charged ions at the two electrodes which would be proportional to their velocities. This would be contrary to Faraday's law and contrary to the facts. The assumption of unequal constant velocities is, therefore, not only incompetent to explain changes in concentration, but it is in direct contradiction to the most thoroughly established facts of electrochemistry."

In the discussion Dr. Wilder D. Bancroft asked whether Mr. Reed denied the occurrence of concentration changes in electrolytic cells. Mr. Reed replied that his paper did not contain any such statement, but that he denied that concentration changes can be explained by different migration velocities. Dr. E. F. Roeber agreed that Mr. Reed's argument concerning the constancy of concentration within the space between his two arbitrary planes in the body of the electrolyte was sound, but he denied that Mr. Reed's argument applied at all to the two spaces between either of Mr. Reed's arbitrary planes and the electrode next to it. The concentration changes occur right next to the electrodes and are accounted for at that place by the theory. Mr. Reed replied that he could put his arbitrary planes wherever he chose, and that he therefore might move them right up to the electrodes.

Work Done in Electrolysis.

A paper on this subject was presented by Prof. J. W. Richards. The object of his research was to determine by a new experimental method the decomposition voltage of a solution, or the voltage which is necessary to set the products free at the electrodes from a given solution.

His method is essentially colorimetric. The experiments are arranged so that one can measure exactly the rise of temperature of the system during the electrolytic action. From this rise of temperature and from the specific heat one calculates the sensible heat evolved during the operation in calories.

At the same time one measures the volts, amperes and the time. This gives the total electrical energy which is put into the cell and which may be expressed in volt-ampere-seconds, or, its equivalent, calories.

This total electrical energy consumed in the cell is the sum of the sensible heat evolved and the chemical work done by the electric current. Hence the chemical work is determined by subtracting the sensible heat from the total energy. Since the latter two quantities were measured in calories, the chemical work is also found in calories and can then, of course, be easily converted into electrical energy units, namely, watt-seconds. The amperes and the time being known, the division of the watt-seconds by the ampere-seconds gives the voltage absorbed in the electrolytic action.

In this way Prof. Richards found that, as a first approximation, the voltage absorbed in setting free hydrogen and oxygen from a dilute sulphuric acid solution is 1.61 ± 0.06; he intends repeating the work with greater refinements so as to fix this datum with an accuracy of 0.01 volt, if the method can be so far improved.

Dr. Richards' paper was discussed at some length. Mr. C. J. Reed asked whether the heat taken away with the gases had been taken into account, and Dr. Richards replied that an approximate estimation showed this heat to be quite negligible. President Carl Hering then brought up the question whether the

energy necessary for the expansion of gases at the electrodes comes from the consumed electrical energy. This is a disputed question, since it might just as well come from the heat of the surroundings. Dr. C. P. Steinmetz appeared to think that this energy is part of the electrical energy consumed. On the other hand, Mr. C. J. Reed pointed out that this is very questionable; for instance, in the electrolysis of an hydrochloric acid solution no chlorine gas is set free at first, but chlorine is evolved in solution and only after the solution is saturated with chlorine the latter is given off in form of free gas.

Prof. F. B. Crocker described some other methods of finding the decomposition voltage. One is to measure the total voltage and deduct from it the resistance drop which can be calculated from the dimensions of the cell and the conductivity of the electrolyte. This would give a check on Dr. Richards' method. Another method is to open the circuit after the current has passed through the cell and measure the counter e. m. f. Dr. C. P. Steinmetz suggested with respect to the latter method to take oscillographic curves of the e. m. f. while the current flows and when the circuit is broken. With respect to the scheme of determining the decomposition voltage from the polarization voltage, Mr. W. R. Mott remarked that condenser effects might disturb the results.

In his reply, Prof. Richards said that just on account of the practical disadvantages of the purely electrical methods he had devised this thermal method. Dr. H. E. Patten asked whether the method was really free from every hypothesis since it was tacidly assumed that there is a definite decomposition voltage.

Recent Developments in Electroanalysis.

What proved to be one of the most interesting papers presented at the convention was Dr. Edgar F. Smith's lecture on the series of researches on electroanalysis carried out under his direction at the University of Pennsylvania. It was an informal speech rather than a paper, but just for this reason it was most delightful as a human document, since it revealed the genial personality of the speaker. To sum up the underlying idea of all this work it may be said that all of it had to do with the application of a mercury cathode and a rotating anode for analytical work. The various apparatus and instruments developed for this purpose were exhibited during the lecture.

For the simplest experiments they used an apparatus which was a modification of a form first proposed by Gibbs, namely, a vessel with mercury in the bottom serving as cathode and a rotating inert anode above which produced agitation of the electrolyte. If copper sulphate is analyzed in this way the copper is taken out by the mercury cathode and after the completion of the experiment it is only necessary to siphon off the solution and weigh the amalgam. This gives the copper. Then titrate the liquid for the acid. This gives the SO_4. This method may be employed in a great many different ways and its application has resulted in enormously reducing the time required for an analysis. The latter is also made very much easier, since it is only necessary to see that the conditions are right and the electric current will do the work properly, swiftly and automatically.

In this way sulphates and chlorides may be analyzed, for instance, gold chloride, barium chloride, sodium chloride, etc. The apparatus for analysis of sodium chloride is especially interesting, since it is a modified Castner-Kellner mercury cathode cell in miniature. It becomes necessary in this case to prevent any action between the sodium amalgam and chlorine. The chlorine is absorbed by the revolving anode, which consists in this case of two silver discs, while the sodium alloys with the mercury and passes outward to the outer cell, on account of the agitation of the electrolyte. In the outer cell sodium hydroxide is produced, which is titrated. The silver anode has also proven successful in the analysis of sodium carbonate, the CO_2 being absorbed by the silver. The

apparatus consists simply of a crystallizing dish, the bottom of which is covered with mercury. Within this dish is placed a smaller bottomless beaker resting upon glass rods, so that there is free communication between the mercury inside and outside. The solution to be analyzed is placed above the mercury within the inner beaker, which contains the rotating silver anode. Water is placed above the mercury in the outer ring.

$K_4Fe(CN)_6$ and $K_3Fe(CN)_6$ can be analyzed in the same way, giving off their anions to the silver anode. In all these cases the anode is rotated at a speed of 150 to 200 r. p. m.

It is also easy to separate different constituents of a mixture of solutions by electroanalysis. For instance, from a mixture of $BaCl_2$, $CaCl_2$ and $MgCl_2$ it is easy to obtain the barium, calcium and magnesium separately by simply adjusting the voltage. The method is easy and quick.

For the electroanalysis of sodium fluoride a similar apparatus may be used as described above for the analysis of sodium chloride. But another anode must be used, namely, one which will absorb fluorine. A rotating lead anode is good, but best of all is an anode of calcium hydrate, that is platinum coated with calcium hydrate.

Dr. Smith described some further achievements and also work which is now going on in his laboratory. The net result of all this work is that by the use of the electric current with a rotating anode and a mercury cathode many analyses have been rendered exceedingly easy and quick. Analyses which required formerly hours may now be finished in 15 minutes or so.

In the discussion, Dr. Bancroft remarked that it is no exaggeration to say that all important progress in electroanalysis in recent years has come from the Harrison Laboratory of Chemistry. Dr. Chandler also expressed his admiration for the "magnificent story" told by Dr. Smith. There was also some reference to Dr. Cushman's work on the electrolysis of feldspar. Mr. Hering suggested a spongy lead electrode, such as used in accumulators, for an anode to absorb SO_4 from a sulphate solution.

PICKLING OF STEEL.

The paper on this subject was presented by Mr. CHARLES J. REED, of Philadelphia. He dealt with a new method of removing an oxide scale from iron and steel by cathodic reduction. The method has already been described in the specifications of Mr. Reed's patents for the process (page 369 of our Vol. IV.). The iron sheets, rods or wire from which the oxide scale is to be removed are made cathode in an aqueous solution of sulphuric acid, preferably of specific gravity 1.20, having an acid content of 27 per cent, with a cathodic current density of $\frac{1}{4}$ to $\frac{1}{2}$ amp. per square inch, at a temperature of 60° C. Under these conditions the heavy scale on rolled iron rods is completely removed in from 2 to 3 minutes.

The chemical reaction is interesting, since it is not reduction of iron oxide to metallic iron (as might be supposed from the analogy with the apparently similar Salom process for lead reduction). As a matter of fact the oxide is reduced simply to a lower state of oxidation and dissolved, ferrous sulphate being produced. The solution of the lower oxide is effected without any of the metallic iron dissolving, as is the case in other processes.

The chief advantages of the process for commercial work are the short time required and the cheapness. As mentioned before the electrolytic process requires only about 3 minutes. Mr. Reed estimates that the process used on a large scale would save from 50 to 75 cents per ton. In the case of a single corporation this would amount to a saving of $3,000 a day.

MEASUREMENT OF HIGH TEMPERATURES.

The first paper of the Friday session was presented by Dr. GEORGE K. BURGESS, of the Bureau of Standards, Washington, D. C. The generally recognized temperature scale up to 1,200° C. is that of the gas thermometer. This scale is fixed by the determination of certain reference temperatures such as melting and boiling points and then preserved and distributed by means of pyrometers calibrated in terms of the temperatures of the fixed points.

The scale as defined by various gases is practically identical. Thus Jacquerod and Perrott, using N, air, CO, CO_2 and O at constant volume get values for the melting point of gold agreeing to better than 1°, and ranging about 1,067° C. Other determinations of the gold point are 1,064° C by Holborn and Day, using nitrogen at constant volume; and 1,065° C. by D. Berthelot by a method equivalent to the constant-pressure thermometer. We may say with considerable positiveness, therefore, that the temperature scale is known to within 3° up to 1,200° C.

There is no difficulty in reproducing the temperature scale by means of the fixed points as sufficiently pure metals may be purchased in the market. Some of these fixed points are the melting point of Sn 232.10, Zn 419.0, Sb 630.5, Cu 1084.1. With the exception of antimony the metals bought from different sources in this country gave practically the same melting points. For aluminium two "chemically pure" samples gave the melting point 655° and 656°, while aluminium from the Pittsburg Reduction Co. had a melting point of 658°.

Above 1,200° C. there is as yet no generally accepted temperature scale, and extrapolation in terms of some phenomenon varying with the temperature must be resorted to. Depending on the phenomenon used different values will be assigned to the fixed points that may be determined.

The author first considers the estimation of high temperatures by means of thermocouples. The usual type of thermocouple is a wire of 10 per cent rhodium or iridium alloy of platinum joined to a pure platinum wire. The relation between the e. m. f. E of such a thermocouple and the temperature t of its hot junction (when the cold junction is kept at 0° C.) in terms of the gas scale is usually given as $E = a + bt + ct^2$. This empirical relation is quite exact in the range from 300 to 1,200° C. By means of this relation determinations of melting points of platinum and palladium by the Bureau of Standards in Washington, the German Reichsanstalt and the British National Physical Laboratory have given very concordant results. The values found for the melting points of palladium are 1,535°, 1,535° and 1,530°, respectively, those for platinum, 1,710°, 1,710° and 1,706° C. Harker found by the same method the melting point of nickel to be 1,427° C.

Expressing results with the ordinary thermocouples in terms of Holman's formula $E = mt^n$, where m and n are constants, the palladium and platinum melting points become 1,543° and 1,731° C., respectively.

Other types of thermocouples give somewhat discordant results when interpreted in terms of these two formulæ. There is no particular extrapolation formula which holds generally for different types of thermocouples, so that there is very considerable uncertainty attached to the estimation of high temperatures by thermoelectric means alone.

The author then took up the discussion of radiation methods for measuring high temperatures. These methods are essentially based on one of two radiation laws, one being that of Wien for light of a single wave length or distinct color, the other being the Stefan-Boltzmann law for the total radiation.

Just as the thermodynamic scale of temperature is independent of the thermal properties of any particular substance, but would be exactly reproduced by an ideal gas, and is very nearly realized by the thermal properties of ordinary gases; similarly, the radiation scale of temperature is independent of the radiating properties of any particular substance, but would be exactly reproduced by the radiation from a "blackbody," and is very nearly realized by the radiation from an almost completely closed furnace at a uniform temperature. The radiation scale then may be and, in practice, is so defined as to be an extension of the thermodynamic scale. It is realized by measuring the intensity of radiation from an uniformly heated furnace of small aperture.

Any other substance than such an experimental black-body will have an apparent temperature, which is characteristic of the substance and kind of radiation, lower than its true temperature, when measured by radiation methods, because a black-body emits radiation of maximum intensity for any temperature. We call *black temperature* the temperature which a black-body would have to give radiation of the same intensity as that emitted by the substance under observation.

In Wien's equation there are two constants and their exact determination is of great importance for application of the formula. Thus, for the melting point of palladium the following three values were obtained in three different researches, 1,541° C., 1,582° and 1,546°; for the melting point of platinum, 1,746°, 1,789° and 1,753°, but the differences between the three values are mostly due to the difference in the value assumed for one of the constants in Wien's formula. More work must be done before the value of this constant is satisfactorily determined.

It is evident that the optical scale, however interpreted, gives temperatures considerably higher than does the extrapolation of either of the two thermoelectric relations given above. The following Table I. gives the corrections that should be added to thermoelectric determinations, making use of equation $E = a + bt + ct^2$ to give temperatures in terms of the optical scale as determined at the Bureau of Standards, which latter scale represents "true temperatures" with greater probability than does the thermoelectric extrapolation:

TABLE I.

Thermoelectric and Optical Scales.

Temp. on Thermoelectrical Scale	1200°	1300°	1400°	1500°	1600°	1700°
Optical-Thermoelectrical..	0	+2	6	14	25	43

It is also possible to make use of the intensity of radiation from the exposed surface of refractory material, as platinum, in order to measure its temperature, when the departure of the substance from ideal blackness has been determined. The relation between the black temperature using red light and the true temperature has been determined for platinum with considerable precision. The readings of an optical pyrometer sighted on a platinum strip may therefore be interpreted readily in terms of true temperatures. Use may be made of this principle to determine the melting points of substances in very minute quantities. As an example, the determination of the melting points of the metals of the iron group in an hydrogen atmosphere is given.

A platinum ribbon, heated electrically, is enclosed within a cylinder which may be filled with pure hydrogen. A very minute quantity—0.001 *mg* is sufficient—of the metal whose melting point is desired, is placed upon the platinum strip. The current is increased until the speck is seen to melt as observed with a microscope through a mica window. Simultaneously the temperature of the strip is measured by means of an optical pyrometer. The results obtained are given in Table II.

TABLE II.

Approximate Melting Points of Iron Group.

Metal.	Purity.	Melting Point.
Iron	99.95 per cent	1,507° C.
Chromium	98.99 "	1,482
Cobalt	99.95 "	1,464
Nickel	99.95 "	1,435
Manganese	98.99 "	1,207

The iron tested above is the electrolytic iron of C. F. Burgess. A pure oxide of metal may also be used in an atmosphere of hydrogen if the oxide is reducible by hydrogen. Thus cobalt from cobalt carbonate and nickel from nickel oxide gave melting points identical with those obtained with the metals. Dr. Burgess recommends the melting point of cobalt as a fixed point, since cobalt is cheap, oxidizes but little and has a sharply defined melting point (1,464° C.).

For higher temperatures than 1,800° C. our knowledge of

the numerical values is still in the formative state. We are restricted here completely to the use of the radiation laws. At the Bureau of Standards in Washington the following method has given good results:

The metal is mounted as a filament in an incandescent lamp, and, by sending a current through, it may be adjusted to the same brightness as a carbon strip, also mounted in *vacuo*. The temperature of the carbon strip is given by an optical pyrometer. Using red, green and blue glasses before the metal filament its black temperatures may be determined as a function of the current. In this way the temperature current relation for the three colors, and thus the selective emission, may be very exactly determined up to 1,900° C.

In general, a substance has an apparently lower temperature for red than for green or blue light, as measured by an optical pyrometer with colored glasses before the eye. True temperatures are approximately obtained by adding to the temperature reading for blue light twice the difference between the red and blue temperature readings. Above 1,900° temperatures are estimated by extrapolation of the current temperature relation found to hold up to 1,900° C.

The melting point is found by increasing the current until the filament melts and noting the current at that instant. In this way the value of the black temperature, using red light of the wave length 0.66 μ, of the melting point of tantalum was found to be 2,742° C. from five determinations. This corresponds to a true temperature of the tantalum melting point of about 2,900° C. Similarly the melting point of tungsten was found to lie between 3 050° and 3,200° C.

The use of an electrically heated ribbon mounted in *vacuo* as a radiating source is very convenient for the calibration of optical pyrometers. With a tungsten ribbon to sight upon in place of the carbon, the direct comparison of optical pyrometers might be carried to very much higher temperatures than heretofore, and with a very small expenditure of energy and time. It does not seem improbable that in the near future, when an optical pyrometer is submitted to a standardizing laboratory for test at three points, it may be calibrated at the temperature of 1,000°, 2,000 and 3,000° C. in less than half an hour.

Finally, Dr. Burgess remarks concerning the Stefan-Boltzmann law for the total radiation that this radiation law has the most satisfactory theoretical basis, but has not been used to the extent that has Wien's law for the estimation of high temperatures. It appears to be much more difficult experimentally to get accurate results using the total radiation methods, or the Stefan-Boltzmann law, than when using the spectral radiation method or Wien's law.

In the discussion which followed Dr. Richards called attention to an error in the value of the melting point of tin given by Dr. Arndt on page 164 of our May issue. It is 232 not 241. This example shows how much confusion still exists with respect to "fixed points." In the use of optical pyrometers the occurrence of metallic vapors is very embarrassing.

Dr. Steinmetz doubted whether the melting point for chromium given in the paper was not too low. He had found the melting point of chromium free from carbon as made by an aluminothermic method to be very much higher. Dr. Richards suggested that a very small amount of aluminium might raise the apparent melting point.

Dr. Henry Noel Potter proposed to pass an inert gas over the melting substance, the temperature of which is to be measured immediately before making a measurement with the optical pyrometer; by this means the trouble due to metallic vapors can be overcome. Prof. S. A. Tucker stated that he also used this method and found it suitable.

ELECTRIC CONDUCTION.

Dr. C. P. STEINMETZ, of the General Electric Co., then delivered an experimental lecture at the special invitation of the board of directors of the Society. While the title was an-

nounced as "Electric Conduction Through Vapors and Gases" he proposed to discuss electric conduction in general.

When electric power flows through a circuit we observe phenomena outside and inside of the conductor. Outside we have electromagnetic and electrostatic stresses, inside we have conversion of electrical energy into heat.

Usually conductors are classified into three classes, metallic conductors, electrolytic conductors and gases and vapors. The best definition of metallic conductors can be given in a negative form; they are those in which energy is directly converted into no other form but heat. It is true that with a high-current density light is given off, but this light is really a temperature effect, and we have primarily a conversion of electrical energy into heat. The range of resistivity of metallic conductors is not very large. The resistivity is approximately constant but has generally a positive temperature coefficient. As an exception alloys may have a negative temperature coefficient.

Secondly, electrolytic conductors are characterized by the fact that the conduction is accompanied by chemical action. The resistivity is about 1,000,000 times higher than that of metallic conductors. The range of resistivity is quite large. They have generally a negative temperature coefficient.

Thirdly, gases and vapors have been the subject of much speculation, and in recent years the ionic theory which was invented to explain, or rather picture, the phenomena in electrolytes has been extended to picturing the phenomena of the electric conduction through gases and vapors. However, these are mere theoretical speculations—hypotheses which may be discarded in time; or as is now the practice in scientific circles, for the sake of continuity, hypotheses are not directly discarded, but amended and reamended until they become something quite different from what they were originally. Dr. Steinmetz proposed to deal only with experimental facts. There are so many sources of error in studying experimentally such phenomena, that he proposed to avoid another source of error, namely, speculation.

There are two distinct classes of conduction through gases or vapors. First, we have the electric discharge; second, we have the electric arc.

The characteristic feature of the electric discharge is that it takes place through the gas or vapor which existed between the two electrodes before the discharge started. The characteristic feature of the electric arc is that it takes place through a vapor which is produced by the arc itself and from the electrode metal. The arc is continuous, the discharge is discontinuous.

A Geissler tube discharge and a mercury arc were shown side by side in a tube which had several connections, high-tension alternating current being available for the discharge and direct current for the arc. The difference between the appearance of the discharge and the arc was very striking. The discharge had an apparently faint luminosity and showed decided striations.

Concerning the nature of the electric discharge much speculation has been produced but very little actual facts are known. More is known concerning the arc. Since in the arc a vapor acts as conductor which is produced by the arc itself and from electrode material, the fundamental question arises as to the nature of the vapor; that is, which of the two electrodes yields the vapor.

This question can be answered by studying the spectrum of the vapor or simply by looking at the appearance of the arc when changing one of the electrodes.

With a positive magnetite electrode and a negative carbon electrode we have the familiar carbon arc. With a negative magnetite electrode and a positive carbon electrode we have the brilliant magnetite arc (iron and titanium spectrum). With a negative magnetite electrode and a positive copper electrode we have the same magnetite arc. This shows that the material which produces the vapor comes from the negative electrode.

For this reason an alternating current cannot maintain an arc in general, since at each reversal of the current the negative electrode stops giving off the vapor, which allows the arc to pass, so that at each reversal it becomes again necessary to start the arc. Only under such special conditions in which an alternating current is able to start an arc again at each reversal an alternating arc becomes possible. This is for instance the case with carbon. Dr. Steinmetz discussed the special conditions which must be fulfilled for an alternating-current arc.

By using a third electrode Dr. Steinmetz showed another phenomenon which is a consequence of the fact that the conducting vapor comes from the negative electrode. He showed that he could shift from positive to positive but not from negative to negative. In connection with these experiments the rectifying effect of an arc was discussed.

Dr. Steinmetz developed the power equation of an arc which states that the e. m. f. multiplied by the current is equal to the circumference of the arc multiplied by the length of the arc and multiplied by the square root of the current. From this it follows directly that the voltage consumed by the arc in the vapor is proportional to the arc length and the arc circumference, and inversely proportional to the square root of the current. There is also a potential drop right at the electrodes.

In the concluding part of his address Dr. Steinmetz pointed out the difficulties in classifying various phenomena in a field of investigation. Thus it is possible to classify conductors into metallic conductors, electrolytic conductors, insulators and arc conductors according to their temperature-resistance curves, but such a classification does not work out right. There are always some materials which do not fit into the classification. The same material may show different characteristics under different conditions. Thus, amorphous carbon has a negative temperature coefficient, but when it is heated to a sufficiently high temperature it assumes a positive temperature coefficient and has for that reason been called metalized carbon.

A whole class of conductors which do not fit into such a classification according to the temperature coefficient characteristics is what Dr. Steinmetz calls the pyro-electric conductors. An example is metallic silicon. According to the range of temperature at which they are used such pyro-electric conductors may show all the different characteristic features of metallic, electrolytic or arc conductors. In general, compounds of the form M^{II}, M^{IV}_2, O_4 are pyro-electric conductors.

While we speak of classification and of the classes of electrolytic conduction, metallic conduction, etc., we should rather speak of them as types of conduction. The most interesting results should be expected from an investigation, not of the typical cases but of bodies laying on the border line.

ELECTRODEPOSITION OF ZINC.

A paper by RALPH C. SNOWDON on this subject was presented in abstract by Prof. W. D. Bancroft. It related to an experimental investigation of the conditions affecting the quality of electrolytically deposited zinc. The variables taken into account were concentration, degree of acidity and alkalinity, reducing agent, current density and temperature. The cathode was rotated in every case and it was first thought that differences in speed would be of minor importance provided a fairly high rate of speed was maintained, but this was found to be a delusion. As a matter of fact the limiting current density at which the deposit begins to become bad depends more on the rate of stirring than on all the other factors combined. The general results of the papers were summed up as follows:

Good deposits of zinc may be obtained from acid or alkaline solutions, even at such high current densities as 60 amps. per square decimeter. The rate of rotation of the cathode has an enormous effect on the upper limit of the current density.

Since zinc will precipitate readily from strongly alkaline solutions, the resistance of these solutions, and consequently the voltage across the terminals, can be made very low for any

given current density. A high current efficiency may be obtained in alkaline solutions.

More finely crystalline deposits are obtained from alkaline than from acid solutions. Increasing temperature or concentration increases the size of the crystals. Presence of formaldehyde decreases the size of the crystals. Increasing the current density decreases the size of the crystals.

A Practical Limitation of Resistance Furnaces—The Pinch Phenomenon.

A very interesting paper on this subject was presented by the president, Mr. Carl Hering. In theory, the electrical resistance furnace is a very simple apparatus; electrical energy is converted into heat in the resistance material with a conversion efficiency of 100 per cent. Theoretically, it might be argued that the only limitations to the temperature are the volatilization of the resistor itself, and in the case of liquid resistors the inability to get a retaining cell or trough which does not itself melt. However, there are other limitations. The one described in Mr. Hering's paper applies to that type of resistance furnace in which the material to be treated forms the resistor, in the form of a column of liquid in a trough, as distinguished from that type in which the resistor is a foreign body like graphite of platinum, which is surrounded or enclosed
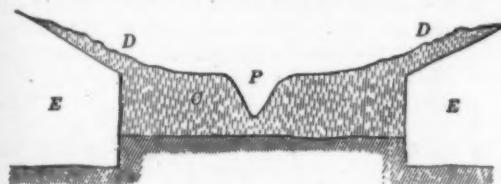
FIG. 2.—PINCH PHENOMENON.

by the materials to be treated. Of these two classes of furnaces the latter is by far the simpler in theory, in practice and in operation. Innumerable difficulties encountered in the former are overcome in the latter, and it is probably a good rule to use the latter whenever possible in preference to the former.

It would be wrong to argue that by simply increasing the watts per cubic inch in a furnace, any desired high temperature may be reached up to that of volatilization, which means a destruction of the resistor. This would be wrong, since the pinch phenomenon, which is the subject of Mr. Hering's discussion, may set a much earlier limit. The phenomenon is as follows:

When the current density in a liquid conductor in an open channel is increased sufficiently, the conductor will be found to contract in cross-section with considerable force, especially at a place where there is some slight obstruction in the channel, or where, for any other reason, the cross-section is less than the average. This contraction resembles the depression in plastic material that has been pinched between the fingers; as the column of liquid looks as though it were being pinched by some mysterious and invisible force, the writer termed it the "pinch phenomenon," for want of a better name.

In Fig. 2 $E E$ are the cold electrodes of such a furnace; C is the column of liquid conductor, which acts as the resistor, and P is one of these pinched contractions. The liquid on both sides of the contraction slopes like the letter V, with inclinations of 45° and over. "The liquid will stay in this position, thus forming a stable state. The inclined surfaces of the liquid, though smooth, showed signs of great internal agitation, as though the liquid was continually running down hill, but was being as rapidly forced up hill again. It was a somewhat curious and interesting sight to see the surface of a liquid sloping at a steep angle and yet be in a stable state. The first impression was that a large leak had suddenly formed, and that the molten metal was rapidly flowing down and out through it; but it was soon found that the condition was a stable one."

When, under these circumstances, the current density is still further increased, this V-shaped depression becomes deeper and deeper until it finally reaches the bottom of the channel; this, of course, breaks the circuit and the liquids then immediately flow together, only to be instantly parted again, thus forming a violent automatic interruptor of the current, accompanied by a sputtering of the metal, loud crackling sounds, and, incidentally, by the great disgust of the man who is running the furnace, as it means that the limit has been exceeded, and if the circuit is not opened at once at the switch, to allow the parted liquids to flow together again to their normal level, there is a strong likelihood that the reduction of the current will cause the core to freeze in this parted condition, which gives rise to serious difficulties in mending the break so that it will carry current again.

If there is any dirt, infusible material or pasty, poorly-conducting slag floating on the surface of the liquid, it will naturally fall into this cavity, and as the conductor in the narrow neck is apt to volatilize, owing to the high current density, while the rest of it is apt to freeze, owing to the reduction of the current, the result is that a complete break is apt to form, through which it may be very difficult and sometimes impossible to start the current again, thus requiring a dismantling and reconstruction of the furnace. It is obvious that this phenomenon places a limit to the current, which can be passed through a liquid resistor of given cross-section, thereby limiting the temperature which can be obtained. This limit may be far below that desired, thus completely defeating the purpose of the furnace. It, therefore, is an important factor to be taken into consideration by the designers of this class of furnace. What the limit of temperature will be, will depend, of course, on the particular circumstances; it is evidently not possible to give any fixed rule. It may, perhaps, be subjected to calculation, but this is doubtful, as this local pinching seems to be originally induced by some obstacle or contraction in the channel, which, being generally accidental, is not within the reach of mathematics.

One of the experiments made by Dr. Northrup, at the author's suggestion, has shown that if the channel is quite uniform, the contraction in cross-section will also be uniform over its whole length, that is, the level of the liquid will lower uniformly, and, therefore, the danger of parting will not be so great. This explains the observation made by the writer that in a furnace of this type, the liquid conductor kept creeping up on top of the cold electrodes, as at $D D$ in the illustration, piling itself up in large quantities and solidifying after it got there. Fresh material had to be added for some time to keep up the level, until the stable conditions were finally reached. This stable condition is different for each current.

To avoid the pinch phenomenon, the channel should be made as perfectly uniform as possible and kept free from obstructions. Further, both depth and width should be made large, which means short channels, low voltages, enormous currents, or else a large capacity of the furnace. In other words, the danger from this source is greatly increased as the furnace becomes smaller in capacity. Some idea of the strength of this contracting force may be had from a case in the writer's experience, in which the V-shaped depression extended down as much as 6 inches through molten iron to the bottom of the channel, causing a complete rupture, followed by freezing, which necessitated the dismantling of the furnace.

The phenomenon has been studied and its theory been developed by Dr. E. F. Northrup, who has made use of it for the construction of simple forms of measuring instruments like those of the indicating and integrating types that measure direct and alternating currents equally well, since the phenomenon is independent of the direction of the current and takes place with either direct or alternating current.

The action may be explained according to Dr. Northrup from the principle that currents flowing in a like direction attract each other, hence all the linear current elements in a con-

ductor are attracted to its center, causing a contraction. On the other hand, Mr. Hering considers the pinch phenomenon to be due to some action of the ever-present encircling magnetic lines of force which are all under tension like stretched rubber bands, and therefore exert a radial pressure on the material which carries the current.

In the discussion which followed, Mr. Reed remarked that he had observed this phenomenon with mercury in 1895, when he observed a breakage of a mercury column and a vortex. Dr. Henry Noel Potter thought that the phenomenon would probably manifest itself in induction furnaces, and in view of the uniform cross-section of the furnace he asked at what place the pinch effect would occur. Mr. Hering answered that it would be most liable to occur wherever there was a little obstruction or irregularity.

The Action of Carbon on Magnesia at High Tempperatures

A paper by Dr. O. P. Watts on this subject was read in abstract, in the absence of the author, by Prof. C. F. Burgess. In building a resistance furnace, magnesite brick was used for -lining and a carbon resistor. The author observed a pitting of the magnesite and the condensation of something that was apparently lamp black. In another case magnesite tubes were baked in carbon. The magnesite tubes disappeared completely, leaving a groove where they had rested in the carbon. Dr. Watts believes that we have to do in this case not with the formation of a compound, but with a physical mixture of MgO and carbon. He could produce a similar substance synthetically by grinding in a ball-mill and mixing. Prof. Burgess was not quite sure whether a compound was not really formed. The paper was discussed by Messrs. Richards, Reed, Bancroft, Potter and Burgess.

Influence of Stress on the Corrosion of Iron.

Dr. W. H. Walker, of the Massachusetts Institute of Technology, presented a paper on a very extended experimental investigation of the influence of stress on the electrolytic corrosion of iron and steel. Without his curves and tables it is impossible to give a full account of the paper but we hope to publish a summary of the chief results in one of our next issues. It may be stated here that the method consisted in measuring the electromotive force in the electrolytic corrosion of different samples of steel under different conditions of stress. Corrections were made for changes of temperature. Dr. Walker investigated the extent to which the e. m. f. is influenced by the stress. One of his results is that as a material adapts itself to the stress the e. m. f. returns to its normal value, so that there is no danger of stresses unduly increasing the corrosion of steel structures.

Polarization Voltages of Silver Nitrate Solutions.

The first paper of the Saturday session related to an investigation of the polarization voltages of silver nitrate solutions by Messrs. J. A. Wilkinson and H. W. Gillette. In the absence of the authors it was read in abstract by Prof. Bancroft. Instead of measuring the decomposition voltage the authors measured the polarization voltage, or counter e. m. f. given by the cell after it had been polarized by a charging current. Four variables were considered: temperature, silver nitrate, acid and water. They let each one of these vary by itself, keeping the other three constant. The chief results of the investigation are summed up as follows:

The polarization voltage of acidified silver nitrate solutions may be made to vary from 0.625 volts to 1.05 volts. It varies with variations of temperature, silver nitrate, nitric acid and water.

The temperature coefficient is approximately 0.8 millivolts per degree over a fair range of compositions and temperatures. A decrease in the concentration of silver nitrate increases the polarization voltage if the concentration of nitric acid be kept constant. A decrease in the concentration of nitric acid de-

creases the polarization voltage if the concentration of silver nitrate be kept constant. The polarization voltage decreases if the concentration of silver nitrate and nitric acid are decreased in the same ratio.

When measured against a sulphuric acid, mercurous sulphate, mercury electrode, the potential difference between silver and the electrolyte is decreased slightly by the addition of nitric acid, while the potential difference between peroxide and electrolyte is apparently increased a great deal. The abnormal result with the silver electrode may be due to a change in the potential difference between the solutions. There is nothing in the data obtained to show whether or when the product formed at the anode changes from peroxide to oxygen.

Rapid Measurement of Electrolytic Resistance.

A paper on this subject was presented by Prof. C. F. Burgess, of the University of Wisconsin. The specific resistance of an electrolyte varies in a marked degree with variations in concentration, temperature and purity. Notwithstanding this fact, comparatively little use of resistance seems to be made in the handling of solutions in technical operations. An increase in the amount of various acids and salts in aqueous solutions from 5 parts to 10 parts per hundred produces a decrease of approximately 50 per cent in the specific resistance, while the
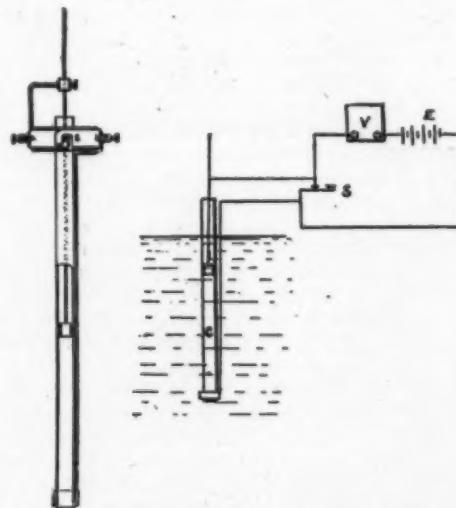
FIGS. 3 AND 4.—APPARATUS FOR MEASURING ELECTROLYTIC RESISTANCE.

corresponding variation in the specific gravity is in the neighborhood of 3 per cent. The sensitiveness, therefore, of a resistance measurement as a means of determining the strength of a solution is materially greater than that of a density determination. The degree with which water approaches purity may be more readily judged by a resistance measurement than by a measurement of its specific gravity.

In technical works, where solutions are handled, the control is usually effected by the use of the hydrometer and by chemical analysis. Devices for the determination of specific resistance are scarcely known outside of the laboratory, though the sensitiveness and range of its measurements are greater than those obtained by the hydrometer. Resistance measurements, correctly interpreted, may, in many cases, enable chemical analysis to be dispensed with. Even in electrochemical work, where specific resistance has a practical significance, other than in throwing light upon the composition of solution, little use is made of this measurement. The electroplater makes daily use of his hydrometer, but knows the "resistometer," if it may be so called, only as a laboratory instrument.

The reason why no use has been made in the past of such methods of industrial work was probably that no simple appa-

ratus was available for this purpose. Prof. Burgess describes a method which has been in use for several years at the University of Wisconsin, and by the use of which the time and trouble required for taking a reading is little greater than that needed for determining the temperature by means of a thermometer, or the specific gravity by a hydrometer.

No new principles are involved in this method, which is based upon the fact that a resistance placed in series with a voltmeter and a source of electrical pressure decreases the voltmeter reading. The apparatus required consists of a glass tube with suitable electrodes, as shown in Fig. 3, a voltmeter of the ordinary type, and a source of constant electrical pressure, such as may be cheaply and conveniently furnished by a few dry cells connected in series. The electrode tube, as illustrated in
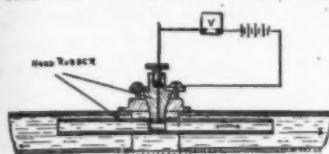
FIG. 5.—TEST OF SOLUTION FLOWING THROUGH A PIPE.

Fig. 3, consists of a glass tube, with its upper end passing through a square ebonite block. Upon this block are mounted the two binding posts, one of which makes connection to an adjustable electrode placed inside of the tube, and the other to a fixed electrode placed outside of the tube near the bottom. The two terminals are kept normally short-circuited by means of the spring s, and this contact may be broken by pressure of the fingers applied at the points a and b.

The operation of the measurement consists in connecting the tube terminals through a voltmeter to a source of constant pressure, as shown diagramatically in Fig. 4. The tube is dipped into the electrolyte so that both electrodes are immersed. The electrodes being normally short-circuited by the switch s, the column of electrolyte c is placed in series with the voltmeter and, consequently, decreases the voltmeter reading.

The resistance of the column of electrolyte c is equal to R' multiplied by the ratio of E — E' to E', where R' is the resistance of the voltmeter, E is the total pressure measured with the switch closed, and E' is the reading of the voltmeter with the switch open. The specific resistance may be derived from this value by knowing the dimensions of the column of electrolyte or by calibrating the instrument with a standard solution.

With the electrodes fixed at a certain distance apart, and with an unvarying source of pressure, a voltmeter may be calibrated so as to indicate directly the specific resistance.

There is an advantage in the fact that the column of electrolyte is at the same temperature as the main body of the liquid; and the instantaneous flow of current, which is necessary in taking the voltmeter reading, cannot heat the electrolyte to an amount sufficient to cause appreciable variation of temperature.

The resistance of the voltmeter should be accurately known and the latter should preferably be of high resistance type. For the highest degree of sensitiveness the dimensions of the column of electrolyte should be adjusted so as to be somewhere near equal to the resistance of the voltmeter. For a tube from 0.5 to 1 centimeter in diameter and about 20 centimeters long, a voltmeter reading from 6 to 10 volts should be suitable when measuring electrolytes of high conductivity.

Care must be taken to avoid polarization between the electrodes. For this reason copper electrodes should be used in copper solutions, etc. Further, the higher the voltage the less is the percentage of error possible by polarization.

Where a record is desired on a solution flowing through a pipe, it may be obtained in the manner illustrated in Fig. 5, where a hard rubber tube within the metal pipe carrying the liquid has a branch which projects through the walls of the pipe, and which carries the wire leading to the electrode. The pipe thus serves as one of the electrodes, the columns of electrolyte, either side of the inner electrode being in parallel.

It is evident that this method of measurement lends itself readily to the use of a recording voltmeter.

In the discussion which followed, Mr. Carl Hering suggested that the apparatus might be used for a substitution method, but Prof. Burgess said that his object was to avoid such a method and to make the measurement as simple as possible. The calculation which is required is also very simple.

ENERGY CHANGES ACCOMPANYING ADSORPTION.

Dr. HARRISON E. PATTEN, of the Department of Soils, of Washington, D. C., presented a paper on this subject. The term "absorption" is used in general to designate the process by which a solid or a liquid draws unto itself and retains within its structure, or on its surface, another solid, liquid or gas. Where a solid retains another substance so that the two form a homogeneous body, the mixture is either a definite chemical compound or a solid solution.

A special case of absorption has been termed "adsorption," which may be defined as the existence of a difference in concentration or density of the film adjacent to a bounding solid, and the concentration or density of the mass of the liquid or gas which bathes this solid.

Whether this absorbed film is in a liquid, solid or gaseous state, or even loosely combined with the solid bounding medium, is not easily determined, and has been the subject of much discussion. The change of state from solid to liquid and liquid to vapor is in general very gradual. All the recent physical researches dealing even with hard polished "solid" surfaces, indicate a mobility of parts, an openness of structure and a high power of retaining foreign material. But the ability of one body to hold another upon its surface is dependent upon the material of which each consists. Consequently, we are accustomed to say that adsorption depends upon the chemical constitution of the solid and of the substance. Another way of stating the same idea is to attribute adsorption to a specific attraction between solid and adsorbed material. It is possible, too, to view absorption as a special case of adsorption, in that where a solid imbibes a solution or a gas, we have an adsorption upon the walls of the fine pores in the solid, as well as a filling of these pores by the liquid or the gas. The first four paragraphs below define more precisely four cases where purely adsorption effects may be expected, and the next three paragraphs indicate the extension of these adsorption phenomena to include cases more commonly considered absorption effects.

1. The simplest case is where a plane surface, such as glass, adsorbs a vapor or a dye from its solution. Here a regular distribution of adsorbed material between solid and solution can be shown.

2. When the surface of the solid is curved the radius of curvature must be taken account of in discussing the effect of surface tension upon the change of concentration near this surface, and for surfaces not spherical the treatment becomes still more complicated as the radius of curvature varies.

3. When the surface incloses a sphere or other form of cell, adsorption is still in evidence upon the inside wall of the cell.

4. Conversely, a sphere or other solid body exhibits adsorption and the curvature of its surface must be considered.

5. Where a solution is taken up by a solid made up of cells, the total abstraction of solute from the main body of solution is produced by adsorption added to the simple filling of the cells with solution.

6. Crystalloids as well as amorphous bodies can imbibe liquid and swell.

7. Consequently, a solid solution may be taken as the limiting case of imbibition plus adsorption.

The author then discussed critically various formulas which have been proposed for calculating adsorption and reviewed the work done in this field during recent years. The concluding part of the paper is a summary of recent work in this field as follows:

Our knowledge concerning the energy changes accompany-

ing absorption was then summarized by Dr. Patten as follows:

Porous bodies absorb gases, even those most inert chemically. Plane surfaces of solids show the same power of retaining gases. The degree of absorption varies with the form and size of the pores; in general, the greater the surface the greater the absorption.

Different substances possess a different absorption capacity. The same substance absorbs different quantities of different gases. Solids exercise a selective absorption toward mixed gases; mixtures of solids absorb a gas additively. Easily condensed gases are in general absorbed more easily.

Heat is evolved during the process of absorption, but this heat is greatly in excess of that given out by the condensation of the vapor to liquid.

At higher temperatures absorption is very considerably decreased. Absorbed gases are held with remarkable tenacity; hygroscopic water is completely removed from glass and mineral surfaces only at temperatures ranging from 500° C. to 800° C. Thus the water is present under its vapor pressure, which at these high temperatures amounts to hundreds of atmospheres, and it is seen why pressure changes within one atmosphere are of little effect upon the absorption, while the initial layer is being adsorbed. The portions of gas absorbed later are held less strongly and are under lower vapor pressure; and for them, the quantity of gas absorbed increases with the vapor pressure, but not according to a simple mathematical formula, although several have been proposed.

The adsorption of gases upon solids is not due to the solution of gas in a moisture layer on the solid, as is shown by the adsorption of gas by bodies which have been heated to redness and cooled in a vacuum. The absorption of gases by solids has recently been shown to render uncertain all of the attempts to measure the temperature of a flame by immersing in it a solid and determining the temperature of the solid. Porcelain and platinum may differ from each other by 400° C. while in the same flame.

The heat evolved upon wetting a powder with liquid is not influenced by the relative quantity of liquid added beyond the certain minimum volume of liquid required to produce the maximum heat effect. The finer the powder the greater heat effect for the same solvent. The heat evolved is different for the same substance wet with different liquids. Soils show a temperature rise upon addition of water of 5° to 8° C.

A powder in equilibrium with vapor at a given temperature and pressure can retain practically as much condensed vapor adsorbed on its surface as when kept below the liquid water at the same temperature and pressure.

In many instances a substance, such as starch, imbibes a liquid and swells. Here we have both imbibition and adsorption, and the heat evolved is, as we should expect, greater than for simple imbibition, and less than that observed where adsorption is the main effect.

When a gas is absorbed by a metal many interesting physical changes in the metal may be effected. Its volume, hardness, elasticity, electrical conductivity and single potential and rate of solution in various solvent liquids are changed. The absorption of a gas, too, may depend upon its condition; that is to say, the energy it possesses. For example, free hydrogen gas is very slightly absorbed by iron and some other metals, but hydrogen freshly liberated from combination either by electrolysis or by action of metal upon acid is very strongly absorbed by the iron. Palladium, on the other hand, absorbs free hydrogen with great avidity.

Radium gives off radiant energy which causes paper to absorb nitrogen and oxygen. Radium emanation is absorbed by charcoal. The paper was discussed by Prof. Bancroft and Prof. Richards.

ELECTRIC REDUCTION OF TITANIFEROUS IRON ORES.

A paper on this subject by Mr. GUSTAVE GIN, of Paris, was then presented. The author referred to the abundance of titaniferous iron ores in many places. They are not used at present, since it seems that troubles have been experienced in attempts of blast furnace men on account of difficultly fusible titaniferous slags resulting from treatment of such ores in the blast furnace.

It is possible that this difficult fusibility of titaniferous slags is caused by an improper calculation of the charge of the furnace. To form a uni-silicate calcium slag requires approximately as much lime as there is silica to be fluxed, but a uni-titanate calcium slag requires only two-thirds as much lime as titanic acid fluxed. It is possible that too much flux is ordinarily used when titanic acid is present with silica in the furnace. Whether this be the fact or not there is no difficulty in fusing silico-titanate calcium slags in electric furnaces.

In 1901, Mr. Gin treated in an electric furnace titaniferous iron ore from Norway of the following composition:

Fe^2O^4 .... 55.73 per cent ⎫
Fe^2O^3 .... 3.16 " ⎬ $Fe = 53.76$ per cent
$TiFeO^3$ .... 30.90 " ⎭ $TiO^2 = 16.40$ "
Si^2O^3 .... 0.56 "
Al^2O^3 .... 3.61 "
Not determined. 3.61 "

The charge was composed of 100 kilograms of ore, 15 limestone, 25 coke, and 274 kilograms was treated in 4 hours, using 286 kilowatt-hours of electric energy, and yielding 102 kilos of metal of the following composition: 94.60 per cent iron, 3.10 carbon, 0.86 silicon, 0.10 titanium, 0.06 phosphorus, 1.28 not determined. The slag had the following composition: 32.50 per cent TiO^2, 20.80 SiO^2, 4.10 Al^2O^3, 8.10 FeO, 32.70 CaO, 1.80 not determined.

The electric energy amounted to 2,850 kilowatt-hours per ton of pig iron. In a larger improved furnace this figure would be certainly not over 2,280 kilowatt-hours.

The above test was made at the French works while the following experiment was made in a German institute of Technology.

Sandy iron concentrate from Java was mixed with limestone and carbon in the proper proportions, and submitted in a resistance electric furnace to a direct current of about 500 amps., at a working tension of 60 to 65 volts. The charge was easily melted; at the end of an hour's running the temperature of the melted mass, taken by a Wanner pyrometer, was a little over 1,900° C. The slag and metal were then cast, the metal in a previously heated crucible; the slag was very fluid and ran easily from the furnace. The clean ingot of metal weighed 42.62 kilos. The slag was black, with glassy lustre.

The analysis of materials and products were as follows:

ORE.	Per Cent.
FeO	28.50
Fe^2O^3	49.95
MnO	0.98
CaO	0.37
MgO	2.35
TiO^2	16.00
SiO^2	1.60
Etc.	0.25
METAL.	
Fe	94.94
Mn	1.52
C	3.05
Si	0.37
P	0.11
S	0.01
Ti	Trace
SLAG.	
SiO^2	8.90
TiO^2	38.72
Al^2O^3	5.18
FeO	10.03
CaO	34.80
Etc.	2.37

The pig iron was very low in sulphur, while the phosphorous it contained came mostly from the carbon used for reduction.

The conclusion drawn from these experiments is that the reduction of titaniferous iron ores in the electric furnace presents no special difficulties, and that pure iron can be obtained commercially therefrom in regions where the ore is near abundant and cheap water power.

In briefly discussing the paper Dr. Richards pointed out the importance of this subject for Canada.

ELECTRIC TUBE FURNACE FOR TEMPERATURE MEASUREMENTS.

Prof. SAMUEL A. TUCKER, of Columbia University, presented a paper in which he pointed out that the measurements of the higher temperatures in the electric furnace is one of considerable difficulty, and this is due for the most part to the presence of fumes derived from the volatile constituents present which obscures the readings of the optical pyrometer.
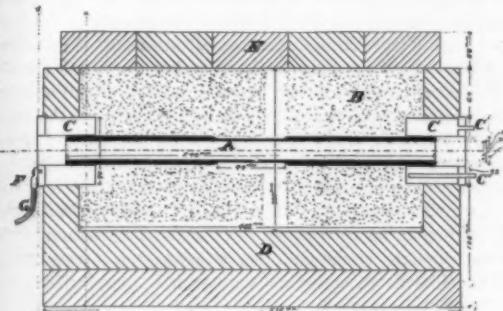
FIG. 6.—ELECTRIC TUBE FURNACE.

In order to eliminate this trouble, Prof. Tucker devised the furnace shown in side elevation in Fig. 6. The current passes through the carbon tube to be heated so that the nature of this material is of great importance. Agglomerated carbon tubes are now made by the National Carbon Co., of Cleveland, and they were found to meet the requirements. The only change in the dimensions made was in turning off a portion in the middle for a distance of about 9 cm., so that the heat is concentrated at this portion of the tube.

A greater difficulty is to find the proper material to surround the tube. It must have a high electrical resistance, it must be very refractory so as to withstand the high temperature, and it must be free from impurities so that no fumes will be evolved on heating. Petroleum coke was found to be the most practical. It is a very pure form of carbon, and is a relatively poor conductor of electricity, and although there is some loss of both heat and electrical energy it does not seem to be excessive.

Two methods were used to unite the carbon tube A to the water-cooled brass holders C. The ends of the tube were copper plated and then soft soldered into the holders, or what appears to be equally good is to pack thin sheet copper or gauze between the tube and the holder. With solder it means dismantling the furnace pretty well when it becomes necessary to put in a new tube, but the soldered joint makes a very sure electrical connection.

The water-cooled holders are of brass, the joints of which are soldered. The end plate of these holders is made heavy to admit of fastening the lugs F by the machine screws. It would be better to braze the joints of this holder, which would make it possible to soft solder in the coppered ends of the carbon tube with ease, so that there would be no danger of starting a leak in the holder.

From the drawing it will be seen that the carbon tube has a total length of 54 cm., an outside diameter of 38½ mm., except for the middle portion, where it is reduced to 31 mm., the inside diameter being 25 mm.

The fire-brick enclosure is 575 mm. x 380 mm., the opening 462 mm. long by 235 mm. wide. This opening is filled with petroleum coke B.

The furnace is covered with carbon or other refractory bricks E. Water is circulated through the holders C by the inlet C″ and outlet C′.

For temperature measurements it is only necessary to place a small graphite boat with a disc at one end to fit the internal diameter of the tube in the middle portion of the tube. The boat will be raised to the temperature of the portion of the tube in which it is placed, and its temperature taken with the optical pyrometer sighted through the end of the tube.

For the determination of the melting points of minerals, refractories, etc., the disc has a small hole bored in it which is covered by the material to be melted. A second observer can then look at the disc through a red glass, and as soon as the hole appears in the disc the temperature is taken. With the pyrometer at one end and the observer at the other end of the tube a close determination of the melting point can be made.

With this furnace, Prof. Tucker was able to obtain the following temperatures with alternating current. With a current of 330 amps. at 6 to 8 volts a temperature of 1,200° C. was reached within 4 minutes, with a current of 600 amps. at 15 volts the temperature was 1,860° after 11 minutes. With a current of 850 amps. at 15 volts the temperature was 2,952° C. after 14 minutes.

GRANULAR CARBON RESISTANCE FURNACE.

A second paper presented by Prof. SAMUEL A. TUCKER dealt with the construction of a furnace using a resistor of granular carbon which is particularly serviceable in laboratory work. The following description applies to a furnace of maximum capacity of 30 to 35 kw.

As shown in the Figs. 7 and 8 the granular resistor A is retained by the magnesia brick F at the sides and the bottom. The electrodes C of Acheson graphite are luted in at E by a

Granular Carbon Resistance Furnace
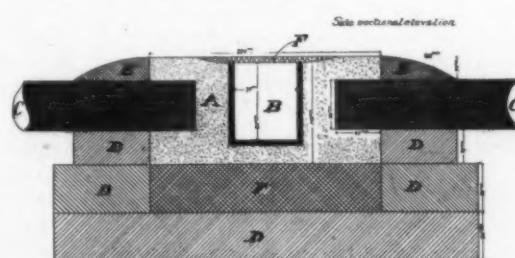
FIG. 7.—VERTICAL SECTION.

cement composed of equal parts of fire-clay and siloxicon. The fire-clay brick work D is laid in the same cement, all joints being closed tight.

The resistor A is of crushed coke, and no particular care is used in grading it to a certain size. It will probably average 20 mesh, and the finer sizes are to be avoided as they will cause blowing which scatters the coke by the gas pressure formed.

The crucible B, also of graphite, may vary in size, but that shown in the figure has been found to give satisfaction, although a smaller size turned from the regular 2-inch electrodes answers in many cases.

A great difference has been found in using coke for the resistor which has been previously used for resistor purposes as compared to fresh coke as it comes from the gas retorts. If new coke is used it will take a much higher voltage to start the run, and great care must be taken not to get too great a gas evolution during the time that the volatile matter in the coke is being eliminated. Otherwise the same blowing will

take place, causing the general upsetting of the furnace. With old coke it is easy to start the run in, and there is little chance of blowing. The crucible can therefore be heated to a high temperature in a very short time.

Indeed, with a furnace of the dimensions shown, Prof. Tucker has been able to reduce any oxide which can be reduced in the arc, with the great advantage that the temperature is more easily regulated and a more uniform product obtained.

The usual difficulty of increasing the carbon contents, due to the retaining vessel being of that material, is naturally present in this furnace as in all others using carbon. It is, however, possible to substitute a magnesia crucible for the graphite if the required temperature is not above the melting point of magnesia.

Alternating current is most suitable for operating this type of furnace, as perfect control may be obtained by variation in the voltage by means of the field of the alternator or by means of an auto-transformer. With direct current the rheostat would have to take very heavy currents and there would be great loss of power.

With a furnace of this size the crucible will not be heated evenly, particularly at the start, for the reason that there is a concentration of the current density at the points directly opposite to the ends of the electrodes. To overcome this objection charcoal may be packed around these points of the crucible. This is easily done by placing a curved piece of sheet iron against the crucible at these points when filling in the coke, so as to leave an open space between the crucible wall and the sheet iron is withdrawn. The charcoal is practically a non-conductor, and causes the current to pass to the sides of the crucible.

A cover turned from graphite is quite suitable to retain the charge in the crucible. For the treatment of a large quantity of material a shaft may be set on the top of the crucible

Granular Carbon Resistance Furnace
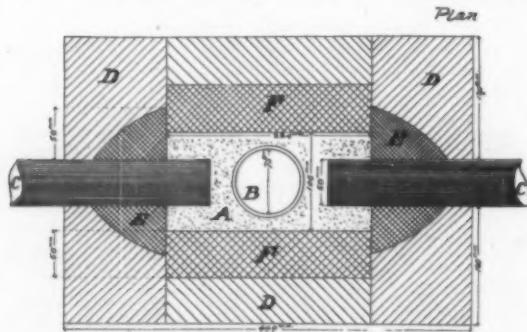
Plan

. FIG. 8.—PLAN DIAGRAM.

proper. The shaft is turned from a graphite electrode and is made to fit within the crucible. For melting oxides, such as magnesia, there is a considerable shrinkage and new material is thus automatically supplied from the shaft to the heated portion of the crucible. This arrangement also acts as a condenser containing any volatilized portion. In the case of magnesia this is important, as at ordinary pressures there is considerable loss of material due to this cause.

On account of the fumes evolved from the ash and the coke as well as the heated brick walls it is exceedingly difficult to determine the temperature by the optical pyrometer in this furnace. Prof. Tucker made, however, several attempts with a graphite tube, the end of which fitted into the crucible and through which the pyrometer readings were made from the side of the furnace.

In the paper some numerical results are given, obtained in the production of titanium carbide, chromium, etc., in this furnace.

Some experiments in running the furnace with new and old coke showed that the time required to reach the same temperature is very much longer for new coke than for old.

In the discussion which followed Mr. Hering asked whether an allowance had been made for the expansion of the tube of Prof. Tucker's tube furnace when it becomes hot. Dr. Tucker said he had experienced no difficulty but if necessary one of the clamps could be so adjusted so as to allow for any expansion. Flexible connections may be necessary in commercial furnaces.

Electrolytic Corrosion of Brasses.

Dr. A. T. Lincoln then presented a paper embodying the results of his very extended experimental investigation for which the American Electrochemical Society had granted him the prize of $100 for original research. The investigation must have involved an enormous amount of experimental work, and it is not possible to do justice to the paper without reproducing all the diagrams, photographs, etc. The following abstract is therefore only an outline of the contents of the paper. After giving the Roberts-Austen diagram of the different phases in which brasses occur the author described the electrolytic corrosion of different brasses in different salt solutions.

For instance, with a sodium chloride solution, as the copper content decreases in the copper-zinc alloy the amount of corrosion decreases until we reach about 50 per cent copper composition. Then the corrosion remains constant and is practically pure zinc corrosion. These results were given in diagrams and analogous measurements were made for sodium nitrate, sodium sulphate, ammonium nitrate, potassium nitrate, etc. In sodium chloride the chemical corrosion is practically parallel to electrolytic corrosion.

The author then dealt with the very characteristic appearance of samples under the microscope after corrosion, pictures of characteristic crystals being given. Finally, complex brasses were also tested by the introduction of small quantities of tin into the copper-zinc alloy.

In the discussion, Prof. Bancroft said that this work had been brought out very clearly, that there is a great multiplicity of phenomena in the corrosion of alloys. We can predict nothing with safety. If it is true that electrolytic corrosion is parallel to chemical corrosion then it is wrong to believe that Muntz's metal is the only one which corrodes in salt water without change of composition; there must be a much wider range. Dr. Richards suggested tests directly using sea water instead of the different constituent salt solutions in it.

The Electrolytic Deposition of Nickel-Zinc Alloys.

A paper on this subject by Dr. E. P. Schoch and A. Hirsch was then presented by Dr. Schoch. In former determinations of the voltages there is a difference of 0.5 or 0.6 volt between the deposition voltages of nickel and zinc. In view of this it is remarkable that no good method for the electrolytic separation of nickel from zinc has been developed. Dr. Schoch then referred to difficulties which they had experienced in plating nickel-zinc alloys from nickel-zinc solutions, and in which they could not get deposits as rich in nickel as they desired. It was therefore decided to first determine again carefully the tension of zinc and nickel, and the chief result of the authors' determination is that they found a higher value for nickel than had been obtained heretofore.

Electric Zinc Furnace.

A paper by Mr. Edward R. Taylor, of Pen Yan, N. Y., was then presented, in which he described a modification of his bisulphide of carbon furnace, especially suitable for the distillation of zinc, lead, etc. The furnace has already been described and illustrated on page 103 of our March issue, to which the reader may be referred. Mr. Taylor remarked that the use of broken carbon as electrode, as introduced by him in the bisulphide of carbon furnace, has proven exceedingly successful in several years' experience on a large scale. It is

very cheap and suitable for continuous operation. While this zinc furnace has already been tried on an experimental scale he has not yet come down to large-scale operation, and a furnace like this can show its full possibilities only on a large commercial scale. This interesting paper was discussed by Messrs. Tucker, Sperry, Emrich and Hering.

ADDRESS OF THE PROVOST OF THE UNIVERSITY OF PENNSYLVANIA.

After Mr. Taylor's paper the regular course of the proceedings was interrupted to give the distinguished provost of the University of Pennsylvania, Mr. HARRISON, an opportunity to address the meeting. He regretted that he had not been able to speak at the beginning of the meeting, but was very glad of the great success of the convention. He assured the American Electrochemical Society that the University of Pennsylvania was always glad to be the host of the Society. He also referred to his own family connections with chemical engineering, the chemical laboratory of the University of Pennsylvania bearing the name of one of the first chemical manufacturers, John Harrison.

After Mr. Harrison had left, Prof. E. F. Smith said he was very glad that the Society had an opportunity to see Provost Harrison, who has done so much for chemistry and for the University of Pennsylvania. To him the University owes its Laboratory of Chemistry, and also a donation of $500,000 for scholarships. Dr. Smith sketched briefly what Mr. Harrison has done in the twelve years of his administration.

This little incident with the speeches of Messrs. Harrison and Smith was highly enjoyed.

CARBON IN ELECTROMETALLURGY.

A paper by Mr. F. A. J. FITZGERALD, of Niagara Falls, and Dr. J. FORSSELL, of Cleveland, was then presented in abstract by Mr. FitzGerald. The authors have made very elaborate tests on the use of amorphous carbon and graphite for electrometallurgical purposes. In view of the extended series of measurements which were made by the authors, only an outline was given in the present paper of the arrangement of the experiments, while all the results were reserved for further publications. The resistivity of various graphite electrodes and amorphous carbon electrodes and the resistance of different types of joints were investigated, etc.

One of the peculiar observations made during the tests was that identical carbon rods in series which should have given the same voltage drop behaved differently inside and outside the furnace. It was found that the carbon inside the furnace always showed a much greater voltage drop than outside, even before the carbon was ever hot. In the discussion several attempts were made to explain this curious phenomenon, but no conclusive results were obtained. We will have an opportunity to return to the very interesting and valuable measurements of Messrs. FitzGerald and Forssell in a later issue.

OXIDATION HEAT OF SILICON.

A paper by Dr. HENRY NOEL POTTER gave details of a bomb calorimeter for measuring the heat of combustion of substances giving solid oxidation products. The author used a bomb calorimeter of the Berthelot type but of a modified construction to suit the special purpose. First, a heavily gold-plated lining was used and later on the lining was modified so that there were two concentric bombs. For details of the construction the reader must be referred to the full paper, which will be published in the *Transactions*.

The chief result obtained with this bomb was the oxidation heat of silicon free from carborundum, which was found to be 7594.8 gram calories per gram of silicon, or $28.4 \times 7594.8 = 215,692$ gram calories per gram equivalent.

In the discussion, in which Messrs. Reed and Richards participated, the latter pointed out the great importance of this numerical value for metallurgical calculations.

ELECTROCHEMICAL PROCESSES AS STATION LOAD EQUALIZERS.

A paper by Mr. JOHN MEYER, of the Philadelphia Electric Company, was in form of a reply to a paper by Mr. Elmer A. Sperry, presented at a former meeting on the same subject.

Mr. Meyer's paper was a discussion of the commercial aspect of this subject from the central station viewpoint, with the hope that electrochemists and electrometallurgists will give this matter further consideration.

The final location of a plant for electrolytic or metallurgical processes, not unlike manufacturing, will result from the knowledge of all costs involved in the process, and not alone the cost of current. To illustrate: A large Philadelphia concern desired a location for its manufacturing plant. Several water-power sites were examined, including Niagara Falls. It was decided, after a careful analysis of all costs (and in the face of cheap water power) to erect the plant in Philadelphia. The actual power cost as determined by several years actual operation indicate that if the lighting company had had the existing rates in force at the time the steam plant was decided upon, the plant installation would never have been made. It would appear, therefore, that the cost of power is not the deciding factor.

Assume the intention to erect a plant for the production of a commodity which we will call "X." What factors should be considered? The following schedule shows graphically the several items which should be considered:
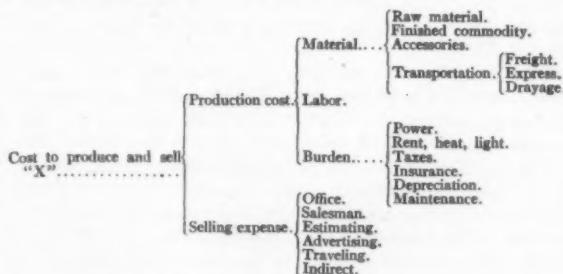
In Mr. Mayer's analysis neither the selling price or the profit was considered, upon the assumption that the selling price is fixed by the law of supply and demand, and the profit will presumably be the difference between the cost to produce and sell and the selling price. Mr. Meyer quoted from a recent paper of Mr. C. J. Russell, of the Philadelphia Electric Company:

"While the tendency seems to be to locate such industries where water power is available, there are other factors which may help the central station to secure consideration in the matter of current supply. The question of facility and low cost of transportation of raw materials and the location of principal market centers for finished product are important to any industry.

"There are some electrochemical industries located now in out-of-the-way places which could obtain better results near some of our great shipping centers, for the reason that the cost of transportation of raw and finished product plus the loss of certain by-products which cannot now be utilized, more than offsets the advantages gained by the price of electricity at the present location.

"While water power may seem reasonable, these items of expense may make central station service in some other and more favored locality the cheaper in the end."

An investigation as outlined above may prove it more desirable to locate an electrolytic plant in Philadelphia in preference to Niagara Falls or elsewhere where such low rates have been quoted. Assuming such to be the case, the problem is then reduced to a comparison between the power costs of central station supply versus isolated plant.

The items enumerated below are those that can generally

be considered as making up the total cost of operating an isolated plant:

Salary of engineers.

Salary of firemen.

Salary of electricians.

Fuel.

Removal of ashes.

Water

Repairs to boilers, engines and dynamos.

Tool account.

Miscellaneous expense

Supplies, oil and waste.

General expense.

Depreciation.

Interest in investment.

Insurance—fire and boiler.

Rental value of space occupied by plant.

Liability insurance.

Taxes.

Having obtained the total operating cost we invariably but erroneously divide this cost by the capacity of boiler, engine or generator and obtain a cost per horsepower or per kilowatt per year. Either result divided by 8,760 hours produces a rate per horsepower-hour or per kilowatt-hour. Undoubtedly the cost per kilowatt-hour is the only correct basis for comparison. However, the foregoing method of arriving at the cost per kilowatt-hour is incorrect, inasmuch as it does not consider the relation between the theoretical and the actual power generated.

The theoretical kilowatt-hour per annum may be found by multiplying 8,760 hours by the rated kilowatt capacity of the generator or the maximum amperes $\times$ volts when all the cells or other apparatus are in service.

The actual kilowatt hours per annum will be a modification of the theoretical kilowatt hours depending upon the time lost in repairs to or overhauling of furnaces, cells, etc. It may be obtained fairly accurately by multiplying the number of pounds of "X" produced in any year by the watt-hours required to produce 1 pound. Dividing the total power cost by the actual kilowatt hours thus obtained will probably produce a rate comparable if not higher than the rate named by the central station.

The fixed charges on the investment necessary to carry the electrolytic load over the central station peak must be considered in making rates. With this peak factor eliminated lower rates could be named.

In conclusion, Mr. Meyer said that central station managers in general are anxious to connect such desirable business and are open to any suggestions that may solve the problem. A great deal of good would result if a committee were appointed, consisting of the interested parties, with instructions to investigate and report at a next meeting.

The paper was discussed by Messrs. Sperry and Taylor.

Mr. Sperry referred to statistical data showing that the average load factor of power stations is about 25 per cent, so that in the average 75 per cent of all the machinery is idle. It would be highly beneficial if all the machinery could be utilized at full load all the time. He also expects much from the development of power from blast furnace gases. Mr. E. R. Taylor expressed the opinion that while electrochemical industries have to take power at present where they can get it, it will be of vital importance for them later on to develop their own power.

Power Costs.

The next paper on the program was on power costs, the author being Prof. Charles E. Lucke, of Columbia University. The paper had originally been presented before the New York Section of the American Electrochemical Society, and printed copies were obtainable at the meeting, together with the discussion in New York by Messrs. F. G. Clark, J. Bijur, L. H. Backeland, C. O. Mailloux, E. J. Berg, P. Torchio, P. R.

Moses, Emmet and M. Namba. The gist of the paper is contained in the following conslusions:

Comparison of power costs on assumed conditions; stations consisting of six units, two in reserve and four working on 24 hours rated load, with the exception of the water power. First cost and fixed charges are based on the capacity of 150 per cent of the output.

	Water Power.	Oil Engines.	Gas Engine and Prod.	Steam Engines.
First cost per kw. rating............	$75.00—200.00	160 kw. units. $217.00	600 kw. $270.00	5000 kw. $110.00—150.00
Fixed charges, rate per cent..........	10 per cent.	10 per cent.	10 per cent.	10 per cent.
Fixed charges, per kw. year.........	7.50— 20.00	21.70	27.00	16.50— 22.50
Operating and mfg. costs per kw. year	1.00— 5.00	56.94	38.54	52.56
Total power costs per kw. year.........	8.50— 25.00	78.64	65.54	69.00— 75.00

"From these figures it appears that we have not yet reached the limit of cost of development of water powers which may be advisable. It apparently would pay to spend even more money than $200, the present maximum per kilowatt for water power development, if there are no other considerations entering. Among the chief considerations of this kind may be set down that of transportation of products from the works and raw material to the works, but this must be considered against the question of transmission of current from the water fall to a convenient point of transportation.

"It is interesting to note how close is the cost competition of the three fuel systems for the conditions assumed for each.

"Excluding the water-power plants, the first cost of the steam plants will be least, oil second and gas engine greatest, with the fixed charges in proportion. As oil fuel is very much more expensive than coal, when referred to the heat contests, and the thermal efficiency of the oil engine not as much greater in general, it follows that the fuel element in power costs will be greater than for the steam or gas plants, except when small and load intermittent. This fuel element will always be less for gas plants than for steam when the same coal is available for both. This fact, compared with the increased fixed charges for gas plants, makes it likely that gas power will be cheaper than steam when the load factor is high, and the difference will be greater the greater the cost of coal. Smaller units in every case will have the effect of increasing labor cost per kilowatt hour, but not in proportion to size reduction. Oil, waste, miscellaneous supplies and maintenance and repairs will depend on the complication of apparatus, its service and the quality of labor employed, but its value is problematic and cannot be predicted, except by experience with similar apparatus, which gives figures on which to base estimates."

In discussing briefly the paper at the Philadelphia meeting Mr. E. A. Sperry thought that Lucke's values were generally too high or too conservative, while on the other hand, Hutton's values (Electrochemical and Metallurgical Industry, Vol. V., page 24) appeared to him too low. Mr. Sperry thought that development would lead to production of power in central station at the cost of $33 to $24 per horsepower-year, or $44 to $32 per kilowatt-year.

Helion Lamp.

Prof. H. J. Parker presented a paper on the helion lamp, invented by Mr. W. G. Clark and developed by him in connection with Prof. Parker. It was pointed out that the higher the temperature of the filament the colder the light. Not the melting point but the point of evaporation is of importance. Pure silicon has a melting point of 1,400° C.; in view of this fact it seemed almost helpless to try silicon for incandescent lamps, since in order to get a lamp of an efficiency of 1 c. p. per watt one needs a temperature of at least 1,200° C.

On the other hand, Prof. Parker claimed that silicon has the

least vapor tension of anything known, and this makes it very suitable for filaments. The chief result of the work in the development of the helion lamp was that they were able to change the ordinary silicon into "metallized silicon," which does not melt up to 2,100° C. He thinks that the "helion" has the same relation to ordinary silicon as the metallized graphite of the "metallized filament" lamp of the General Electric Company has to ordinary carbon.

Since a carbon core is used for the filament and silicon is coated on it, the hypothesis had been offered that the filament was really carborundum or a silicon carbide. But Prof. Parker doubted vigorously that it was carborundum, and did not think it was a silicon carbide although he could not absolutely deny the latter possibility. He preferred to believe in the hypothesis of a "metallized silicon." The lamp has an efficiency of 1 c. p. per watt.

In the discussion Mr. Clark called attention to the temperature-light curve. Take the characteristic of the carbon filament, then coat it with silicon and take again the characteristic. At any point the light is increased for a certain temperature. Mr. Gaster, a delegate of the Faraday Society, and Prof. Tucker also took part in the discussion, and in his reply Prof. Parker said that at the end of 1,230 hours the decrease in candle power of some lamps tested was only 3 per cent, but other results were obtained with other lamps and no conclusive results were yet available.

SURFACE PROPERTIES OF ALUMINIUM AND ZINC.

Mr. W. J. HAMMER, of New York City, lectured briefly on some experiments which he had made concerning peculiar surface properties of aluminium and zinc. It is well known that the surfaces of these metals are generally coated in the ordinary atmosphere with a film which is assumed to be an oxide film. The presence of this film has very distinct effects. Mr. Hammer believes that microphotographs would give good information on the subject. On the other hand, he has also made purely mechanical tests, for instance, with drops rolling on surfaces on differently inclined grades, etc.

PAPERS READ BY TITLE.

The following papers were read by title, and since no printed advance copies were available it is impossible to abstract them here. The papers will be printed in full in the *Transactions*:

"The Electrometallurgy of Zinc and Its Relation to Present Practice," by WOOLSEY McA. JOHNSON.

"Moissan's Life and Work," by Dr. G. F. KUNZ.

"Carborundum, Artificial Graphite and Artificial Diamonds," by Dr. G. F. KUNZ.

"On the Density of Certain Fused Salts and Their Mixtures," by Dr. H. M. GOODWIN and R. D. MAILEY.

"The Present Status of the Thermodynamic Scale," by E. BUCKINGHAM.

EXHIBITION.

During the meetings an exhibition of various instruments and apparatus interesting for electrochemical and chemical engineers had been arranged in one of the rooms of the John Harrison Laboratory. Demonstrations of these instruments were made after the close of the meeting on Saturday.

The LEEDS & NORTHRUP Co., of Philadelphia, exhibited various measuring instruments, among them their type K potentiometer, regulating rheostats and a Kohlrausch slide-wire bridges and an ammeter based on the "pinch effect."

The WILLSON-MAEULEN Co., of New York City, exhibited several tubes of electroquartz, suitable as pyrometer tubes and for other purposes

The DECKER ELECTRICAL MANUFACTURING Co., of Philadelphia, exhibited several Decker primary cells for automobile use as well as special porous diaphragms of their manufacture for other purposes (see our Vol. IV., p. 441; Vol. V., pp. 58, 104, 144 and 195).

Messrs. EIMER & AMEND, of New York City, exhibited several electric furnaces, a muffle furnace, electric stirrers, hydrometers and other instruments.

During the Saturday session Mr. HENRY G. MORRIS described briefly the Kestner evaporator which is designed by Mr. Paul Kestner, of Lille, France, and is now being introduced in this country.

Film evaporation has been known and recognized for many years as the most effective and most desirable method of concentrating liquors. Various attempts have been made to secure a uniform distribution of the liquor over the heating surface, which has resulted in great complication of circulating pumps, float valves, deflectors and regulators of various forms. In some of these attempts have been made to make the film of liquid adhere to the outside surface of heated horizontal tubes. In these forms of evaporators great care must be taken that the liquid is distributed in an even film over the tubes, and furthermore, the liquid is always tending to fall from the tube before the maximum concentration takes place. The float valves and circulating pumps give more or less trouble, and the distribution boxes require careful adjustment.

The feature of the Kestner climbing film evaporator is that the distribution of the film over the heating surface is rendered automatical and does not require pumps, float valves and distribution boxes. The film is spread over the heating surface by the disengagement of the steam instead of the reverse as usually takes place.

The tubes in a Kestner evaporator are ordinarily vertical and are about 23 feet long. The liquid is fed at the bottom and the supply is so limited that the tubes are practically empty. At the start the liquid begins to boil in the tubes and very shortly such a violent ebullition occurs that the vapor, occupying many times the volume of the liquid, rushes through the tube at such a velocity that it carries with it against the hot walls of the tube a thin film of liquid, which, together with the vapor, is discharged against suitably designed vanes of a centrifugal separator. By means of this the concentrated liquid is whirled against the walls of the vapor belt, and the vapor, thoroughly separated from the liquid, passes off to the next pan or to the condenser.

VISITS, EXCURSIONS AND SOCIAL FUNCTIONS.

After the close of the meeting on Wednesday the members were the guests of the University at luncheon in Houston Hall, on the University grounds.

After luncheon an inspection was made of the chemical and engineering laboratories of the University of Pennsylvania.

This was followed by a visit to the large experimental plant of the United Water Improvement Company, where the electrical production of ozone for water purification was shown. Two different types of ozonizers are used side by side, one employing a glass dielectric, the other no dielectric whatever. The latter system is that of Vosmaer. The sterilization of Schuylkill water (after previous filtration) by means of a stream of ozone gas bubbling up through a long tube in which the water runs down was shown outside of the building. The claims were made that the effect of ozone treatment on Schuylkill water, which contains besides various organic substances 3,000,000 bacteria per cubic centimeter, was to oxidize completely the organic matter and to reduce the number of bacteria to less than 5 per cubic centimeter, the power consumption being 1 kw-hour per 1,000 gallons of water.

A visit was then paid to the large plant of the John F. Lewis & Bros. Co., where the manufacture of white lead and red lead was shown. For the evening of Thursday a theater party had been arranged to Keith's Theater, Chestnut Street.

On Friday afternoon an excursion on the Delaware was enjoyed. The city of Philadelphia, through the kindness of the Mayor and the Director of Public Safety, had tendered to the members of the Society the use of the city fireboat *Ashbridge*. The boat took the party first to Tacony, where the enormous

saw works of Messrs. Henry Disston, Sons, Inc., were visited. This company was the first in the United States to introduce the electric induction furnace into practice for the manufacture of high-grade steel of crucible-steel quality. The success has been so great that they are now considering the installation of a much larger electric furnace plant. The original furnace (a photograph of which, taken when at the Disston works, is reproduced in Fig. 9) has been removed from the works to a building near Lardner's Point Pumping Station for a series of very careful tests. Here the furnace was shown in operation to the members.

This furnace was manufactured by the Induction Furnace Co. of America under the patents of Mr. Edward A. Colby. It is rated at 131-kilovolt amperes. The voltage of the single-phase primary current is 240 volts, the maximum current 540 amps, and the frequency is 60. The primary consists of 28 turns of copper tube, ⅜ inch inside and ⅝ inch outside diameter, and is cooled by internal water circulation. The annular crucible which, with its contents, forms the secondary of the transformer furnace, is a one-piece crucible, 14⅞ inches inside and 24¼ inches outside diameter, 8 inches in height. The trough is 6⅛ inches deep, 2 7/16 inches wide at top and 2 inches at the bottom, with a working capacity of 190 pounds of steel. The current in this crucible is, at a maximum, 15,148 amps. at 8.57 volts.

Ingots of 90 pounds can be poured every hour, leaving 100 pounds in the crucible. Fresh materials are then added at once. The fusion is complete in half an hour. The refining and killing takes the other half-hour. The steel lays very still in the mold. The ingots are very dense and homogeneous.

The present-size crucible requires 40 kw. at the maximum. The current regulation is practically controlled by the amount of metal in the crucible. External control is only necessary to control the temperatures during refining and boiling out gases.

The current used per 100 pounds of metal poured varies from 27.5 to 37.5 kw-hours, according to the nature of the charge and the percentage of carbon desired in the finished product. It was stated that the pinch effect has never been observed in this furnace. The calculated resistivity of steel is of little use in calculating the amount of current required in the primary, as the section of the current is constantly altering, due to liberated gases.

The members then visited the Lardner's Point station, where Mr. Charles J. Russell, of the Philadelphia Electric Co., had prepared a very interesting exhibition and demonstration of various models of electric furnaces. This exhibition is shown in Fig. 10.

The furnace at the left of the picture is a kryptol furnace,

kryptol being the well-known granular carbon resistance material. This furnace is very convenient for melting 2 or 3 pounds per crucible of metals or alloys. Plates of Acheson graphite are placed at each end of a chamber built up of refractory materials, and the crucibles are plunged into kryptol, which is packed around them. Different temperatures are obtained in each crucible by taking off the cover and reducing the depth of kryptol around the one to be heated to the higher point. The furnace consumes about 7 kw. and is operated at 110 volts. By inserting resistance in the circuit the temperature may be readily controlled. Ordinary operations require current for 20 minutes when starting with cold materials.

The next furnace, No. 2, was an arc furnace with two electrodes, something on the order of the Héroult furnace which has been used for reduction of magnetite by charcoal in the well-known tests at Sault Ste Marie. The small experimental furnace holds 100 pounds. The arcs are produced between
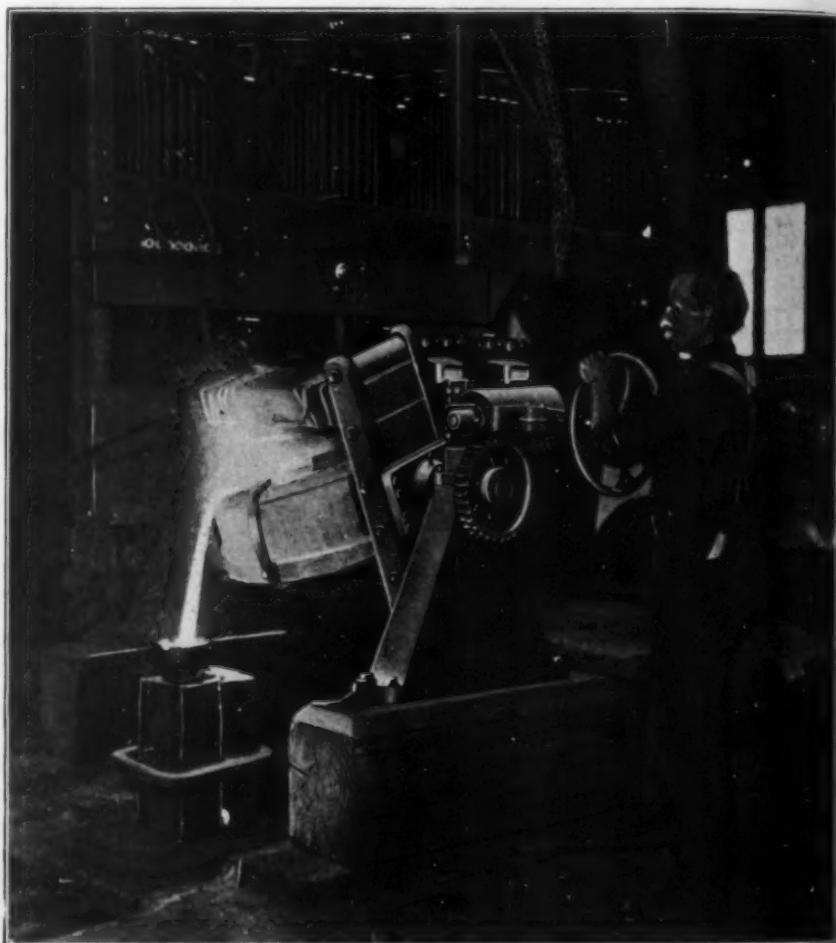
FIG. 9.—COLBY ELECTRIC STEEL FURNACE.

the electrodes and the slag on top of the metal. From 300 to 500 amps. at from 35 to 40 volts are used at each electrode, making the total power consumption in the furnace from 21 to 40 kw. This furnace has been used experimentally in reducing iron ores. Fine grade of steel has also been produced by starting with pure concentrates and subsequent refining in an induction furnace.

The third furnace shown was a single-electrode arc furnace of the type used by Siemens, Willson, Héroult and others. In this case the crucible and its contents are connected to one pole

of the circuit and the moveable electrode to the other. The current used in this model is from 300 to 500 amps. at 35 to 50 volts, which represents a total capacity of from 10.5 to 25 kw. This model has been used principally in the production of carbides of various metals. The furnace was shown in the

PHOTOGRAPH TAKEN ON EXCURSION BOAT.   PRESIDENT
HERING AND PRESIDENT-ELECT BURGESS IN FRONT ROW.

course of making titanium carbide. The character of the arc was very noticeable. The furnace may, of course, be used both with alternating current and with direct current.

The fourth furnace is a barium-chloride furnace of the type

understand that same samples of high-speed steel were recently hardened in Philadelphia in this furnace. There was absolutely no effect on the surface of the steel and the pieces come out as pretty a finished product as can be imagined.

The electrodes of this furnace are of wrought iron. The bath consists of fused barium chloride for temperatures above 1,000° C. For lower temperatures a mixture of chlorides of barium and calcium is used. This is the first furnace of commercial size shown in this country. The size of the bath is 7⅞ x 7⅞ x 10⅜ inches. It takes about half an hour to heat the furnace up thoroughly, and the power consumption ranges from 8.5 to 12 kw. A wide range of temperature is possible by adjusting the voltage. Since the current density in the molten bath is practically uniform the temperature within the bath, except in the thin layer in the upper surface, is found to be very uniform.

In coal or gas-heating of articles made of high-speed steel for tempering, sharp corners are broken down and sizes are altered by scaling due to oxidation. On the other hand, articles treated in this electrically-fused chloride bath come out perfect. Articles requiring to be heated to a high temperature, such as high-speed tool steels, can be immersed in the bath without oxidation and other chemical action and can be quickly brought up to the required temperature. The field for the application of this furnace seems very large and important.

Upon the bench on the right of Fig. 10 was exhibited a device for heating a combustion tube by means of kryptol. This consists of an inner and outer containing tube with a kryptol powder packed between them. Contact is made by terminal blocks of Acheson graphite. A wide range of temperatures may be obtained by the use of supplementary resistance control. On the same bench two small arc furnaces of the Moissan type were shown in operation. A small model of an induction furnace was of interest, as showing the principle of the construction of this type of apparatus.

The furnaces shown in this exhibition were installed expressly for the occasion, and were with the exception of the barium-chloride furnace, models of types used in experimental work by Mr. C. J. RUSSELL, who should be sincerely congratulated for his success in arranging this very interesting exhibition as well as for his good and persistent work in bringing central station men and electrochemists together.
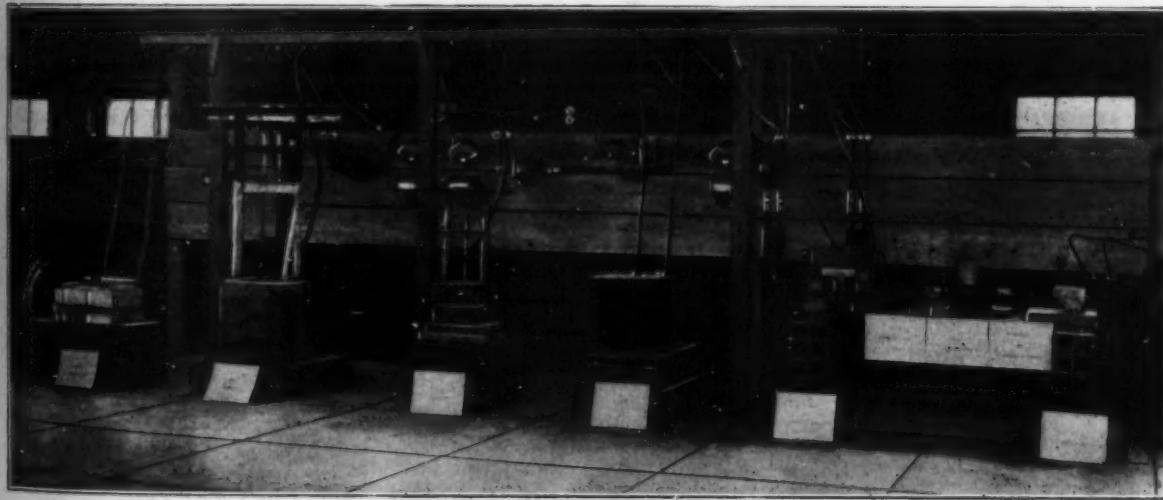
FIG. 10.—EXHIBITION OF ELECTRIC FURNACES AT LARDNER'S POINT STATION.

controlled jointly by the Allgemeine Elektricitäts-Gesellschaft, of Berlin, and the General Electric Co. in this country. It is specially adapted for use in hardening and annealing, and has met with considerable success in this field and in European countries. (See also pp. 367 and 514 of our Vol. IV.) We

The party was then taken back to the boat for a ride down the Delaware, passing the Philadelphia and Camden water fronts with all their large industries, including Cramp's ship yards, the New York Shipbuilding plant, the By-Product Coke Ovens, the sugar refineries, the League Island Navy Yard, etc.

After arrival at Gloucester a visit was paid to the works of the Welsbach Light Co. All the different steps in making and finishing an incandescent gas mantle could be seen in the different departments, and the way it is being done, to have such very delicate things produced on a large scale almost exclusively by young girls, with the aid of special machinery, was greatly enjoyed by the visitors.

The boat then took the party to Washington Park, where the landing of the shad nets was seen (though with some difficulty on account of the darkness) and a planked shad dinner was enjoyed afterwards. After-dinner speeches were made by President Carl Hering, President-Elect C. F. Burgess, Dr. C. P. Steinmetz, Prof. Wilder D. Bancroft, Prof. J. W. Richards, Dr. Charles Baskerville and Mr. W. J. Hammer. Mr. H. B. Coho was as ever an excellent and jovial toast master.

On Saturday, after the demonstration of exhibits, the members were again the guests of the University at luncheon at Houston Hall. A visit was then paid to the United States Mint, at Seventeenth and Spring Garden Streets, where the electrolytic plants for the refining of gold and silver were visited under the direction of Dr. D. K. Tuttle and Mr. Leonard Morgan. The Wohlwill process in use there has been described in detail in our Vol. I., p. 157, and our Vol. II., pp. 221 and 261. The Tuttle process of refining silver and the whole process of refining both gold and silver at the Mint was described in our Vol. IV., p. 306.

The meeting as a whole was a full success in every respect and was exceedingly enjoyed by all who attended it. The number of members who registered were 123, besides eight guests, but the attendance at the meetings was at times larger rising to a "peak load" of more than 180 during Dr. Steinmetz's lecture on Friday.

For the first time in the history of the Society quite a number of ladies participated in the excursions and contributed much to their success and enjoyment.

The next meeting of the Society will be held in Autumn in New York City.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

METALLURGICAL RESEARCH AT THE NATIONAL PHYSICAL LABORATORY DURING 1906 AND 1907.

The report of the executive committee of the National Physical Laboratory for last year is, as usual, a document of much scientific interest, not least upon its metallurgical side.

The chief work of the year of this section has been the research into the properties of the alloys of aluminium and copper, which is embodied in the eighth report of the alloy research committee of the Institution of Mechanical Engineers. In addition the alloys research committee have asked for certain further tests on some of the copper-aluminium alloys, particularly as to their behavior in tension at high temperatures (i. e., up to 500° C.) and their behavior when exposed in the sea for long periods of time. Preliminary arrangements for carrying out this work have been made; for tensile testing at high temperatures an electrically heated furnace has been designed and its construction is in hand. The "furnace" is tubular and the specimen is heated by radiation only. By means of this appliance it is hoped that tensile tests on specimens 2 inches between gauge marks may be carried out at any desired temperature up to at least 500° C.

For the sea-water corrosion tests arrangements are being made for specimens to be exposed in the sea at Portsmouth, where they will be accessible for periodical inspection.

Investigation of a further series of alloys, probably of aluminium, will be undertaken and carried out on lines similar to those adopted in the case of the copper aluminium alloys, but the alloys research committee have not yet definitely decided what alloys are to be studied.

Cooling Curve Methods.—An investigation of the differential method of taking cooling curves has been begun, and indications of interesting results have already been obtained; this work will be continued, and it is hoped that a paper embodying the results will be published early in the year.

Eutectic Alloys Research.—It is proposed to investigate the physical structure and mechanical and thermal behavior of eutectic alloys. At the present moment there is a marked gap in our knowledge of these bodies. The physical structure of pure metals and the changes which this structure undergoes when the metal is mechanically deformed, as also the process of crystallization and crystal growth both at and below the freezing point, have been very fully studied, principally by the aid of the microscope, by a number of investigators, and the conclusions reached command wide acceptance. The eutectic and "eutectoid" bodies are, however, not nearly so well understood and have been very little studied from this point of view, probably because their usually minute structure renders the study more difficult than in the case of pure metals. It is thus at the present moment an open question whether the structure of "eutectic and eutectoid" bodies is, like that of pure cast metals, truly crystalline or not—the phrase that at a certain temperature an "eutectic crystallizes" being based chiefly on the analogy of homogeneous bodies such as pure metals of solid solutions. Even if the generally crystalline character of these bodies be admitted or assumed, the detailed nature of the crystalline arrangement remains to be determined so as to decide whether there is any uniform crystalline orientation throughout a "grain," consisting of many lamellæ of both constituents of the eutectic, or whether each lamella is an individual crystal. Spherulitic structures may also occur. It is further to be decided whether eutectic bodies are alike in this respect or whether different modes of solidification prevail in different groups of elements. In another aspect of the same question the thermal behavior of the eutectic alloys is to be studied; it is well known that by suitable thermal treatment the two constituents may be caused to separate or segregate more and more completely, and it is important to determine the course of the process of fusion in such a case; i. e., to determine whether the melting point is raised by such segregation and what intermediate stages—if any—occur prior to actual fusion; the study of transition products in the formation and fusion (or absorption) of eutectic or eutectoid bodies is of special interest in connection with the less known structural constituents of steel ("sorbite" and "troostite"). It is hoped, however, that careful study of these phenomena upon the following lines may throw some light on the causes of the relatively very low melting points of the eutectic alloys.

(1) Preparation of as great a variety of "eutectic" and "eutectoid" bodies as possible in a state of approaching purity —including the exact determination of their composition and melting and freezing points. Of the series so prepared, characteristic members are to be selected for further study.

(2) Study of the micro-structure of the eutectic bodies and the effects of slow and rapid cooling and other heat treatment on the structure.

(3) Study of the microscopic effects of strain upon these bodies as differently treated; microscopic study of the mechanism of plastic deformation and of the path of fractures produced in various ways—the results being correlated, where possible, with the mechanical properties of the alloys in various conditions. (2) and (3) above make a very severe demand upon the capacity of the microscope, since it is probable that some of the features to be observed lie at or even beyond the limits of ordinary microscopic resolving power. The limits of microscopic resolution have, however, recently been pushed considerably further by the introduction of

microscopic appliances for the utilization of ultra-violet light of short wave length (0.275), yielding *effective* magnifications up to 3,000 diameters, and it is proposed to apply this apparatus to the study of the minute features referred to above.

(4) The processes of solidification and fusion to be studied thermally and microscopically, by means of heating and cooling curves and by the examination of specimens suddenly cooled at intermediate stages of both processes.

(5) The formation of eutectic bodies without the intervention of fusion; *i. e.*, by diffusion of solid metals with and without the aid of pressure, and by electric deposition and study of the structure and properties of the bodies so formed.

(6) Formation and study of ternary and quaternary eutectic alloys.

The engineering department have also a schedule of interesting work to be undertaken in 1907.

(1) *The Resistance of Materials to Impact.*—As the chief object of this research is to determine the simplest and best method by which a measure of the capacity of a given material to resist shocks can be obtained, it is proposed to carry out a larger number of tests on about one dozen samples of steel and iron of the kind in commercial use at the present time. These tests will be made on each of the three impact testing machines which have been already constructed in the workshop, and on the Izod impact tester lent by Messrs. Avery. The experiments with these four machines will, it is hoped, reveal the relative merits of the "single blow" method and the "repeated blow" method. Concurrently with these tests statical tests are being made on similar specimens to determine the total work done in fracture, so as to be able to compare the values so obtained with the energy of the blow to cause fracture in the impact test. In the case of the specimens tested on the machine for alternating direct stresses due to impact, it is proposed to subject them to microscopical examination during the progress of the tests and to obtain photographs of the gradual development of the slip lines into cracks.

It is then proposed, by means of the methods of testing developed in the preceding research, to undertake the investigation of the properties of certain materials which have proved weak under shock without apparent cause, and for this purpose to invite engineers in practice to send samples of such materials to the laboratory. Capt. Sankey and Mr. Stromeyer have already kindly offered to help the laboratory in this matter. It is further proposed at the same time to investigate the effect of various kinds of heat treatment on resistance to shock in the case of iron and steel.

(2) *The Elastic Limits of Material Under Alternating Stress.*—For the paper on alternating stress which has been published certain experiments were made on the elastic limits of specimens which had been subjected to a considerable number of reversals of direct stress, which showed an agreement of the range between the elastic limits as determined by a sensitive extensometer and the range of stress for which fracture will just not occur after indefinite repetitions of the stresses.

It is proposed to add to these preliminary results and to further examine specimens of iron and steel with the object of arriving at a definite conclusion. By subjecting these materials to a number of reversals of stress of a range less than the limiting range and examining by means of an extensometer, it is hoped that the change due to an increase in the range of stress can be followed from the primitive condition to the limiting condition corresponding to the limiting range of stress. All the preliminary experiments bearing on the point indicate a complete absence of elastic range for repetition of all stresses of greater magnitude.

(3) *The Resistance of Materials to Repeated Tensions Between Given Limits.*—In the discussion of the paper on the "Resistance of Iron and Steel to Reversals of Direct Stress," the opinion was expressed that experiments on the effect of repeated tensions should also be undertaken. As a fairly

simple modification of the alternating stress testing machine constructed for the previous work will enable such experiments to be made, it is proposed to investigate during the present year the resistance of specimens of similar forms to those machine details in which the load varies between definite limits in tension, such as connecting rod and cross-head bolts, cylinder cover studs, etc.

BRITISH ELECTROCHEMICAL PATENTS EXPIRING IN 1907.

Nowhere is the process of evolution so vividly brought to mind as in the library of the Patents Office. Perusal of the records, while it reveals any quantity of impracticable ideas, also enables the student of such matters to trace, step by step, the way in which a fairly well-known apparatus now in use has been evolved from the complicated and expensive form in which it had its beginning. The following patents, for instance, dealing more or less directly with the electrolytic production of hypochlorite of sodium, contain many of the details to be observed in the more advanced plants of the present day. The apparatus covered by No. 5197 (Hargreaves) was, strictly speaking, intended for the production of electrolytic alkali, with the covering clause "for electrolysis generally." It consists of a vessel or tank divided into three compartments longitudinally, the two interior divisions being formed by the two plates. The negative was of wire gauze protected by a porous diaphragm, and the positive of carbon blocks. Liquid was admitted at the top on the cathode side, and filled the chamber between the two plates, draining off through the porous diaphragm to a pipe at the bottom of the tank. On the far side of the anode a pipe was provided for the escape of the chlorine gas.

This apparatus was further improved by the use of a special combined cathode and porous diaphragm, described in the specification to patent No. 5198 (Hargreaves & Bird). This was formed by the depositing of a fibrous material and a binding agent (such as asbestos and lime) on the wire gauze forming the cathode, drying the plate thus formed, and finally steeping it in a solution of silicate of soda or potash in order to convert the lime (magnesia, baryta, or other suitable substance) into an insoluble silicate. This patent would appear to indicate that the original diaphragm had been found insufficiently permanent in character.

Under No. 11,973 Messrs. Siemens Bros. & Co. and Engen F. A. Obach patented an apparatus for electrolyzing water, consisting of a cylindrical vessel, which may be of cast iron, cylindrical in form which is closed by a cover whence is hung a second cylinder reaching part of the way down the vessel. To the lower edge of this cylinder is attached the upper edge of the diaphragm of iron wire gauze, whose lower edge is fastened to a base of ceramic or other material at the bottom of the vessel. The vessel was to be charged with a solution of caustic soda or potash. Apparently the combination of a bell collector such as is commonly used in the electrolysis of water, with a diaphragm.

No. 13,336 (C. Hoepfner) is described by the inventor as "a bath with insoluble anodes of carbon, platinum, or other suitable material separated from the cathodes by a membrane resisting mechanical and chemical action." This bath is intended for the precipitation of nickel and cobalt by electrolysis. The patent covers the use of a revolving, oscillating or vibrating cathode, and of diaphragms of nitrated cotton or nitrated linen, which may be thickened and strengthened with asbestos, and mechanically protected by a grid or sieve. The apparatus is to be used with chloride solutions of the metals.

No. 18,173 (J. Hargreaves and J. Bird) relates to a cell or tank divided into partitions by plates each protected by a diaphragm. Each pair of plates forms a pocket, and between each pair is a space. At the top of this space a pipe enters the side of the tank and squirts liquid on the diaphragms on either side. The liquid penetrates the diaphragm and keeps the intermediate electrolyzing space full, draining off again at the bot-

tom of the tank to an outlet provided there for the purpose.

Other interesting electrical patents for the same year (1906) are Nos. 6,565, 10,584, 13,339, 13,340, 13,847 and 21,707. No. 6,565 (Messrs. Siemens Bros. & Co. and E. F. A. Obach) is for structural improvements in dry cells. The cell described consisted of a zinc cylinder cemented to an insulating base, preferably of an asphalt of paper pulp. In the center of this cylinder is fixed a carbon rod surrounded by a depolarizing mixture. This consists of about 50 or 60 per cent of manganese peroxide, and about 40 or 50 per cent of plumbago, mixed with one per cent of gum tragacanth. This mixture is moulded into a hard cylinder, and placed between the central carbon and the zinc outer box. The space between the depolarizer and the zinc is filled with a mixture of 80 to 90 per cent of plaster of Paris, and 10 to 20 per cent of flour, made into a thin paste with ammonium chloride solution. Over the whole is a layer of granulated cork, and a sealing compound. A claim is also made for the method of setting the terminal in the carbon by use of an alloy expanding as it solidifies.

No. 10,584 (H. Y. Castner) is an improvement on Patent 16,046, of 1892, which relates to a process for forming an amalgam or alloy between Hg and sodium, which latter, after being deposited in the Hg, is moved with it to a second compartment, where it is separated to form caustic soda. This patent claims the cell, the rocking apparatus (a cam under one end) and the combination of the two.

No. 13,339 (A .C. Girard and E. A. G. Street) is a patent on an improved manufacture of carbons for electrical purposes. Ordinary carbons are converted into graphitic carbon by carrying them to a welding heat either by passing them, bit by bit through an arc, by passing a heavy current through the carbon, or by playing an arc on the carbon.

No. 13,340 (A. C. Girard and E. A. G. Street) is for improvements in electric furnaces in which the crucible is one pole, and one or more carbons are let down into it, completing the circuit. Claims are also made for a carbon casing for separating granular materials from the arc, and the provision, in connection with a furnace, of a magnetic field for causing the rotation of the arc or arcs.

No. 13,847 (R. A. Hadfield). A simple apparatus for ensuring greater uniformity in manganese steel. A crucible is hung on a weighing machine and manganese placed in, the steel being afterwards added from a second ladle.

No. 21,707 (E. Andreoli) is an improvement on a former patent for the production of ozone by electric discharge from numerous points, whereby the same process is made to produce illumination simultaneously with the ozone. This is effected by the use of a glass tube having inside a carbon filament and outside some serrated wires or other metallic electrode. These two wires are connected with a Ruhmkorff coil.

THE FARADAY SOCIETY.

At the meeting on March 19, for which four papers were announced, Dr. Lowry presided.

Mr. NUTTON read the paper, prepared by himself and Mr. H. D. LAW, on the "Potential of Hydrogen Liberated from Metallic Surfaces," somewhat in extenso.

Mr. Rhodin, opening the discussion, said the question referred to was one of the most important in connection with metallurgical work. In his own experiments he had for some time past noticed the irregularities referred to in the paper. The barometric pressure was all important, and this he did not see noted in the paper. To put it vulgarly, hydrogen could get off a —— sight easier at low pressure. (He then sketched on the board certain curves relating to the dissolution velocity of manganese bronze.. Other experimenters, such as Caspardi, and a Russian whose name he forgot, had obtained absolutely different results, which he accounted for by their working under different barometric pressures. In talking about a gaseous state, a standard temperature must be fixed.

Dr. Bjorn pointed out that the previous speaker was not alone in his observation that a difference was made by the atmospheric pressure.

Mr. Rhodin asked for the figures given by other experimenters, which Dr. Bjorn could not give.

Mr. Wilsmore made some remarks as to the influence of supertension in reduction. He also asked why ordinary cadmium was not used instead of cadmium plated on platinum.

Another speaker referred to two tables (Table 10, No. 5, and Table 4, No. 2) in the paper as showing practically the same result. In using aluminium and platinum, the aluminium became plated with platinum and then behaved as a platinum electrode.

Mr. Law said the barometric pressure was not very important. The pressure of hydrogen on the electrodes had been calculated, and shown to be enormous. There were all sorts of explanations as to the increase of the e. m. f. between the cathodes and anodes, including that of films on the cathode. The results obtained were extremely high in starting, and fell afterwards. When a reducing agent such as benzaldehyde was added the e. m. f. rose. To explain readings apparently contradictory, we suppose that metal exists in two forms, one with a high super-tension, and one with a lower. It was certainly so with iron, aluminium, nickel and platinum.

To explain the insensitiveness of zinc to arsenious hydrate, he submitted that samples of zinc occurred which arsenious oxide would not reduce. Such metal contained impurities, such as Cu, of low super-tension. If these were covered with cadmium it was all right. These experiments were to find how far cadmium would cover the platinum. With a thin coating the super-tension would be found to be that of the platinum base, and not of the cadmium. This agrees with other results, indicating that the cadmium should be thicker.

Dr. Lowry thought the problem was a difficult one, and the authors had at present only pointed out more intricacies.

The second paper on "Electrode Potentials in Liquid Ammonia," by Dr. Johnson and Mr. Wilsmore, was then briefly outlined by Mr. Wilsmore.

Dr. Lowry thought the different components of the ammonia solutions might account for the difference noted in the paper, to which Mr. Wilsmore agreed.

Mr. RHODIN then being called upon to read his paper on "The Independence of Solutes in Solvents as Manifested by Osmotic Pressure," said he was not going to read a paper so much as to ask the members a conundrum. (He drew a diagram showing a tube standing in a vessel, in which tube liquid rose by "so-called osmotic pressurce.") Now by applying a condenser at the top, the evaporated liquid could be got to flow, there you have a form of natural energy.

Dr. Lowry observed the diagram represented one of the commonest forms of heat engine.

Mr. Rhodin (interrupting) said that was evident, but the problem was why the liquid rose in the tube.

Mr. Wilsmore said that Mr. Rhodin appeared to have a nomenclature of his own. He did not think the interpretation given in the paper to the term "free energy" corresponded with the meaning generally understood. He also said that the effects which the argument indicated resulted from a special value given to p in the gas law.

With regard to the statement on the last page of Mr. Rhodin's paper, he did not regard a substance as having potential energy because it had a tendency to absorb energy from the outside.

Dr. Lowry said that Van t' Hoff's theory explains the direction of motion of osmotic flow. The mechanical view of the structure of the membrane had been generally abandoned. The one of the difference in size between solvent and solute molecules had the support of Kahlenberg, Nernst and others.

Mr. Rhodin said that he wished to attack the problem as it was presented in 1887, not as it appeared in 1907. We could not explain why the rise of liquid took place except on the supposition of the absorption of outside energy. Mr. Wilsmore's

objections were only a little arithmetic, which did not touch the main problem.

Dr. SLATER PRICE's second contribution to the study of "The Electrolytic Deposition of Zinc using Rotating Electrodes" was taken as read owing to the lateness of the evening, and the meeting broke up.

THE OFFICIAL NOMINATION FOR THE NEW COUNCIL OF THE FARADAY SOCIETY.

The Faraday Society is to be congratulated on the strength of the additions to its council. Lord Kelvin, retiring from the presidential chair, Dr. Ludwig Mond (vice-president) was asked to succeed him, but owing to ill-health was unable to comply. Sir William Perkin therefore is nominated for the presidential chair. Among the vice-presidents, Prof. Hittorf, Sir William Huggins, Prof. A. Crum-Brown and Prof. J. J. Thomson remain. The retiring vice-presidents are Sir Oliver Lodge and Lord Rayleigh, vacancies being filled by Prof. Huntingdon (who vacates his seat on the council on this promotion), Mr. R. A. Hadfield (past president of the Iron and Steel Institute) and Prof. A. Schuster.

Of ordinary members of council, Mr. Bertram Blount, Mr. W. R. Cooper, Mr. Jackson and Dr. Steinhart retire by rotation, leaving still in office Dr. Hutton, Dr. Lowry, Mr. W. M. Morrison, Mr. Swinburne and Prof. E. Wilson. New members are Mr. Beilby (returning after the statutory period of self-denial), Mr. A. C. Claudet, Mr. S. Z. de Ferranti, Mr. F. W. Harbord and Mr. Wilsmore.

To praise individual names is almost invidious, but much satisfaction is expressed at Mr. Hadfield's acceptance of nomination. Mr. Harbord has been a familiar figure and author of important papers, while Mr. Wilsmore is a hard worker among the rank and file.

MARKET QUOTATIONS DURING APRIL.

In the chemical trade the following changes are recorded: Ammonia sulphate, increase of 5s. per ton to £35; copper sulphate has been affected by the fluctuations in the price of copper, and finally closed at £32.10. The coal tar and soda products are unchanged, but of the potash products, potassium carbonate (90-92 per cent) is 7s. per ton cheaper at £19.10.6, while, on the other hand, Montreal potash (in store Liverpool, is £1 cheaper) at £39 per ton. Shellac has been in good demand, closing at £10.19 per cwt.

In the metal market, the early part of the month was marked by the decline in the price of copper to £92.10 per ton on April 3. By the 9th it had rallied to £99.10, receded to £93.5 by the 15th, subsequently rising steadily to £104.10 by the 30th. Tin moved somewhat similarly, receding from its opening price of £185.15 to £181.5 on April 4, rallying by the 10th to £186.17.6, and after weakening to £184.2.6 rising steadily to £195. Lead has been rather more varied than usual, starting at £20 it touched £20.17.6 on April 22, fell back to £20.5 by the 25th, and closed at £20.12.6.

The upward movement in iron prices is very pleasing. Cleveland pig iron which opened at 54s., closed at 58s.3d. per ton, the highest price of the year. Scotch pig iron advanced from 61s. to 65s.9d., and hematite closed at 76s.9d.

LONDON, May 4, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACES.

Silicon as Reducing Agent for the Production of Chromium, Tungsten, Etc., and Their Ferro Alloys.—F. M. Becket, 854,018, May 21, 1907. Application filed Sept. 23, 1905. (Assigned to Electro Metallurgical Co.)

The patent refers to the use of metallic silicon as reducing agent in the production of chromium, tungsten, molybdenum and vanadium and the alloys of these metals with iron or nickel. The special object is to produce these metals or alloys low in carbon and low in silicon. The process will be understood from the description of the manufacture of ferrochrome from chromite. As the chromium in chromite exists as chromium sesquioxide, Cr_2O_3, and practically all the iron as ferrous oxide FeO, the following reactions take place:

$$2Cr_2O_3 + 3Si = 4Cr + 3SiO_2$$
$$2FeO + Si = 2Fe + SiO_2$$
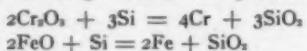
A fair commercial grade of chromite contains 52 per cent Cr_2O_3 and 16 per cent FeO, and 100 pounds of this ore will therefore require, according to the above reactions, 17.7 pounds silicon for complete reduction of the chromium and iron. A representative analysis of ferrochromium made by this method is as follows: Chromium 71.00 per cent, iron 28.40 per cent, carbon 0.50 per cent, silicon 0.10 per cent. It is advantageous to use the silicon in a fairly fine state of division, and the metal is generally crushed so that it will all pass a 10-mesh screen. However, the state of division of the silicon depends on the scale of the operation. The use of a basic flux in the production of ferrochromium is not essential although advantageous. Most commercial chromites contain from 8 to 15 per cent Al_2O_3 and 8 to 15 per cent MgO. These materials serve as basic flux for the silica present in the ore and for that produced by oxidation of the silicon; but the proportions are such that to maintain this slag fluid for tapping, a higher temperature is necessary than that required for complete reduction of the chromium and iron oxides by silicon. In the case in which very low silicon content is required in the alloy (less than 0.2 per cent), chromite is used in very slight excess above the theoretical proportion; while in the case in which a silicon content as high as 1 per cent is permitted the silicon is used in very slight excess. In the second case the yield of metal from the ore is slightly higher. The inventor carries on the reduction continuously in the electric furnace in which the current passes through a molten bath of a mixture of ore, silicon and flux, and from which part or all of the metal or slag may be withdrawn as desired. He feeds the mixture to a bath which is constantly maintained at a temperature higher than that necessary to cause some reaction. The use of silicon as a reducing agent is claimed to have the following advantages over the use of aluminium; a relatively large weight of metal reduced per unit weight of reducing agent; the comparative ease of finely dividing silicon; the fact that the reaction proceeds more quietly and with less loss of material; finally, silicious ores which are relatively inexpensive may be successfully used.

Silicon as a Reducing Agent for Producing Metals and Alloys from Sulphides.—Fred. M. Becket, 855,157, May 28, 1907. Application filed March 5, 1907.

While the process is applicable to sulphide ores, concentrates, matte, etc., in general, it is stated to have particular advantages for the production of molybdenum and vanadium from their sulphide ores, according to the equation, in the case of producing molybdenum from molybdenite,

$$MoS_2 + Si = Mo + SiS_2.$$

Commercially pure ferro-molybdenum or ferro-vanadium or the corresponding nickel-molybdenum or nickel-vanadium alloys may be produced by smelting in an electric furnace a

mixture of molybdenum or of vanadium sulphide, with a silicon alloy such as ferro-silicon or nickel-silicon, the alloy being preferably used in approximately the proportions required to supply sufficient silicon to unite with the sulphur of the sulphide. It is not essential that the proportion of silicon to sulphur should be precisely that indicated by theory, for in case a product very low in silicon is required the sulphide should preferably be used in excess of such proportion; whereas if a certain proportion of silicon is permissible in the product an excess of the silicon or silicon-bearing reducing agent may be used. The operation is preferably rendered continuous by adding fresh portions of the charge from time to time and withdrawing the product as desired. By smelting the charge in a close chamber and protecting the products from oxidizing influences the sulphide of silicon may be collected, but in open smelting furnaces both of the constituent elements of the sulphide unite with oxygen, yielding silica in a state of minute sub-division and sulphur dioxide; these products may be collected and utilized. The substances to be treated by the process must be finally sub-divided.

ELECTROLYTIC PROCESSES.

Electrolytic Production of Sodium.—F. von Kuegelen and G. O. Seward, 850,376, April 16, 1907. Application filed May 4, 1905.

It has been proposed to produce sodium by electrolyzing fused sodium chloride with a molten anode of a heavy metal, as silver or copper, so that the chlorine liberated at the anode forms a chloride with the heavy metal. The trouble which has always been experienced with such processes is that the chloride thus formed did not remain at the bottom of the
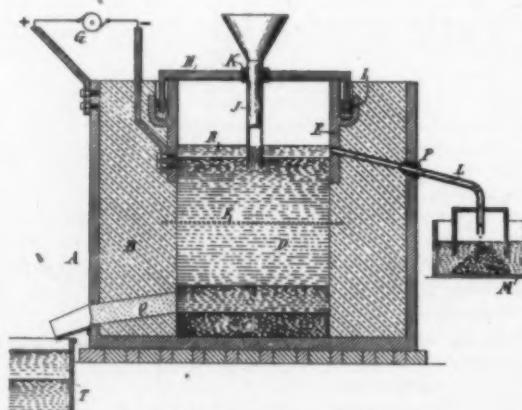
FIG. I.—ELECTROLYTIC PRODUCTION OF SODIUM.

electrolyte but soon began to rise, with a resulting deposition of the heavy metal, instead of sodium, on the cathode. The present inventors design their cell so that all disturbing factors which would cause the chloride to rise upwards are avoided. Since the chloride has a higher specific gravity it has a natural tendency to remain at the bottom. The cathode is located in the upper part of the electrolyte as remote as possible from the heavy anode and the chloride formed at the anode is periodically removed. A diaphragm of foraminous metal such as iron wire cloth is interposed between the cathode and the chloride of the anodic metal whereby the latter is confined beneath the diaphragm. The use of such a metal diaphragm is rendered possible by the absence of free halogen or other electronegative agents which would otherwise corrode and destroy the metal. The inventors also point out that it is necessary to construct the cell of a sufficiently large diameter.

The cell is shown in Fig. 1. A is an iron cathode having a lining B of fire-clay or magnesia, etc., containing at the bottom a pool of molten lead C which forms the anode. Above

this anode flows the body of the molten sodium chloride to be electrolyzed D, and at the upper part of the electrolyte it comes in contact with an annular cathode E of cast iron forming part of the outer wall of the cell. F is the diaphragm which may consist of one or more layers of iron wire cloth. The cell is hermetically sealed by an iron cover, through which projects a feed pipe J for introducing fresh electrolyte, its lower end being sealed in the electrolyte. The sodium R formed flows on the electrolyte and is discharged through the tube L into a vessel M containing oil. S represents the lead chloride formed which is at intervals run off through the tap hole Q.

Electrolytic Cell.—Anson G. Betts, 850,127, April 16, 1907. Application filed May 11, 1904.

This patent refers to the construction of an electrolytic cell for such purposes in which the anolyte is kept separate from the catholyte. It is said to be particularly adapted for the electrolysis of ferrous sulphate, copper sulphate solutions for the production of metallic copper and ferric sulphate. The tank 1 in Fig. 2 (which shows a vertical longitudinal section and a vertical cross-section) is divided into a series of compartments by means of transverse partitions 3, which are separated one from another along their bottom edges by sills 4, resting on the bottom of the tank, and along their vertical edges by uprights 5 of the same width as the sills 4 and seated in notches in the sills. Each sill and the pair of uprights seated thereon constitute a spacing frame adapted to separate from one another by a definite distance the two partitions on opposite sides thereof. The sills 4 may extend the whole width of the tank; but the partitions are of less length than the interior width of the tank, and the uprights 5 are erected in line with the vertical edges of said partitions, thereby leaving a pair of longitudinal chambers 7 and 8, extending along the opposite sides of the tank from end to end thereof. The alternate compartments formed by said partitions and spacing frames are in communication with the longitudinal chambers 7 and 8 by means of inlet-apertures 10, formed in the upper portion of the uprights adjacent to the chamber 7, and outlet-apertures 11, formed in the lower portion of the uprights adjacent to the other chamber 8. The other compartments are closed to both chambers 7 and 8. The compartments closed to the chambers 7 and 8 are adapted to contain the anolyte in contact with the anodes 12, while the other compartments, as well as the chambers 7 and 8, are adapted to contain the catholyte in contact with the cathodes 13.

The partitions separating the compartments are made of wood having numerous perforations which are filled with wads of asbestos. A pipe 18 leading from a supply of air under pressure, is projected nearly to the bottom of the tank, and the air escaping from the lower end of the pipe and rising through the catholyte causes it to rise to a level higher than the general level of the catholyte in the remainder of the vat and to overflow the bottom of the aperture 16, through which it passes into the neighboring chamber 7, tending to raise the level of the catholyte in that chamber. The catholyte thus caused to flow into the chamber 7 is taken from the chamber 8 through the bottom opening 11 in the adjacent upright at the end of the compartment having the well, through which compartment it passes beneath the inserted partition 15 into the well. The result of this operation is a constant tendency to raise the level of the catholyte in the chamber 7 and reduce its level in the chamber 8, causing a gravity flow of the catholyte through the upper apertures 10 into the respective cathode compartments and through the lower apertures 11 out of said compartments.

For the purpose of securing circulation of the anolyte along the opposite sides of the vat a pair of troughs 19 and 20 are provided, supported upon horizontal cross-pieces 21, interposed between the vat walls and the ends of the partitions and the spacing uprights. The trough 19 is connected with the bottom of each anode compartment by means of a siphon tube 22, which extends up over the spacing upright adjacent to the

trough, and in like manner the trough 20 is connected with the upper end of each anode compartment by a siphon tube 23, which extends up over the neighboring spacing upright. At one end of the vat is provided an exteriorly-located well 24, with the lower end of which the trough 19 is connected by means of a siphon tube 25, and with the upper end of which the trough 20 is connected by means of a tube 26. A pipe 27 leading from a supply of air under pressure is projected nearly to the bottom of the well, and the air thereby deposited near the bottom of the well rises in bubbles through the anolyte, raising the level of the same in the well above the general level of the anolyte and causing a flow through the tube 26 into the trough 20. This operation tends to continually lower the level of the anolyte in the trough 19 and to raise its level in the trough 20, causing a flow through the siphons 22 and 23 from the trough 20 into the upper ends of the respective anode compartments and through the siphons 22 from the lower ends of the anode compartments back into the trough 19.

The cathodes 13, which are in the form of plates, are suspended by means of hooks 30 from metallic cross-bars 31. The anodes 12 are in the form of rods depending from metal cross bars 36 of a carriage 37, mounted upon rollers 38, adapted to

FIG. 2.—DIAPHRAGM CELL.

rest upon and travel longitudinally along the top surface of the side walls of the vat. To-and-fro movements can be imparted to the anode carriage by means of the lever 41, and it is stated that these movements materially diminish polarization and increase the life of the anodes. A reciprocating motion of 1 inch amplitude has been found to give good results. For the electrolysis of copper iron sulphates, the catholyte may consist of an aqueous solution containing about 4 per cent of iron in the form of ferrous sulphate, 2½ per cent of copper in the form of copper sulphate, and 2 per cent of free sulphuric acid, and a suitable anolyte may consist of an aqueous solution containing about 3 per cent of iron in the form of ferric sulphate, 1 per cent of iron in the form of ferrous sulphate. ¾ per cent of copper in the form of copper sulphate, and 2 per cent of free sulphuric acid, the same being substantially free from halides. By the term "halide" is meant the simple combination of a halogen or cyanogen with an element, ammonium or equivalent.

Diaphragm for Sodium Chloride Electrolysis.—Leo H. Baekeland, 855,221, May 28, 1907. Application filed March 10, 1906. Assigned to Development & Funding Co.

This patent is evidently an outcome of Dr. Baekeland's work in developing the Townsend cell on a large scale—an account of the Niagara Falls plant using this process being given by Dr. Baekeland on another page of this issue. The present patent refers to a new preparation of the diaphragm separating the anolyte from the catholyte. To the surface of a base consisting of woven asbestos fabric, commonly known as asbestos cloth, a permeable coating, paste or paint, is applied, consisting of an oxide of iron such as Venetian red or Indian red, asbestos powder or equivalent filling of ferric or ferrous hydroxide. This paint may be prepared by precipitating 400

cc. of ferric chloride solution having a specific gravity of about 1.4 by an excess of caustic soda, and adding to the resulting alkaline mass and thoroughly incorporating therewith about 500 grams of ferric oxide and 1,200 grams of asbestos powder, together with sufficient water to convert the mixture into a rather thick paint. Such mixture is uniformly spread over the asbestos cloth and permitted to dry thereon, when the diaphragm is ready for use. The excess of caustic soda above referred to is desirable, as it distinctly aids by its cementing effect in the production of a coherent and durable coating. Ferrous hydroxide is the equivalent of ferric hydroxide for this purpose, inasmuch as it becomes wholly or partly converted into ferric hydroxide during the drying of the diaphragm. It possesses over ferric hydroxide the advantage of economy, since it is readily prepared by dissolving scrap iron in commercial muriatic acid and precipitating the resulting ferrous chloride solution.

Electrolytic Production of Aromatic Alcohols.—Charles Mettler, 12,654, May 21, 1907. Application filed March 20, 1906.

The process refers to the reduction of aromatic esters to alcohols, for example, of the ethyl ester of benzoic acid to benzyl alcohol. The aromatic ester is electrolytically reduced at a metal cathode of high cathodic tension, for example, at a lead cathode. The ester is dissolved in concentrated sulphuric acid diluted with water, or alcohol or acetic acid. In lieu thereof an aqueous alcoholic solution of hydrochloric acid can be used, etc. The product consists partly of benzyl alcohol and partly of benzylethylether, which latter boils at a temperature of 185° C. The invention is not limited to the various esters of benzoic acid but relates generally to the whole class of aromatic esters. The relative quantities of alcohol and ether produced vary in different gases and appear to depend on the constitution of the compound being reduced.

Plating of Ceramic Vessels.—S. Heller and C. Baumgartl, 850,753, April 16, 1907. Application filed August 5, 1905.

A metal coating is first produced by melting onto the ceramic article finely-divided gilt-enamel tombac, together with a mixture of enamel and calcined borax. Gilt-enamel tombac is a preparation or alloy which is fire-proof up to 1,200° C. It is practical to mix two parts of enamel with one part of calcined borax and one part of finely-divided gilt-enamel tombac. Gilt-enamel tombac may consist of substantially three parts of copper, one part of zinc and one-eighth part of gold. This mixture is put onto the ceramic objects to be coated and is burned in, as. for example, in a muffle at a temperature of 800° C. After the article has cooled off the surface of the fused or burned-in coating is ground, abraded or polished, so that a clear metallic surface appears. The article is then placed in a galvanic bath, in which electrodeposition takes place, so that thereby the outer metallic envelop is plated, thickened and strengthened to any suitable degree. The article is then ground and polished. The metal coating thus produced adheres with exceeding firmness to the base.

Electrolytic Wool Washing and Cleansing Apparatus.— G. D. Burton, 854,028, May 21, 1907. Application filed Aug. 11, 1905. (Assigned to American Electrical Process Co.)

Mechanical details of construction of a vat for electrolytically washing and cleansing wool and other textile substances, such as cotton, hair, flax, etc.. The patents refer

simply to details of construction of the vat with a revolving drum for agitating the electrolyte, but the nature of the electrolyte is not stated.

BATTERIES.

Storage Battery.—E. Sokal, 852,464, May 7. 1907. Application filed May 4, 1906.

During charging a lead cell, the concentration of the sulphuric acid electrolyte increases because SO_4 is taken out of the plates into the electrolyte. Reversely during discharge the concentration of the electrolyte decreases. Since these changes are the result of the chemical reactions directly at the active surface, that is, in the pores of the plates, the concentration increases rapidly within the pores during charge far more rapidly than in the body of the electrolyte outside of the pores. During discharge the concentration decreases rapidly within the pores and far more rapidly than in the body outside. It has long been recognized that these facts are at the bottom
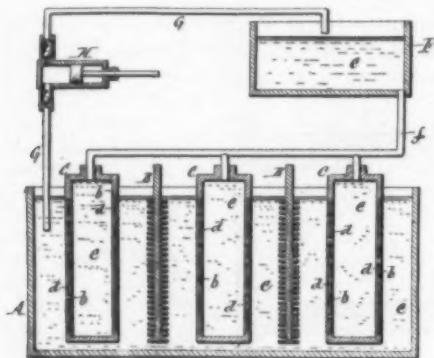
FIG. 3.—STORAGE BATTERY.

of many characteristic features and troubles of storage batteries. They explain, for instance, the drop of e. m. f. during discharge and the greater drop and smaller capacity at higher discharge rates. The present inventor endeavors to overcome these difficulties by artificially maintaining the concentration of the electrolyte uniform throughout the whole cell. For this purpose he pushes or forces the electrolyte through the electrodes during charging and discharging. The construction is shown in Fig. 3, where B are the negative electrodes and C the positive electrodes. The latter are constructed in the form of hollow skeleton frames or grids with openings b in the walls which contain fillings d of lead peroxide. The space within the hollow electrodes as well as the space in the jar which surrounds the positive and negative electrodes is filled with the electrolyte e. The level of the electrolyte on the inner side of the hollow electrode is higher than that on the outer side thereof, so that the force of gravity will have the effect of pusing or forcing the electrolyte from the inside of the hollow electrode outwardly through the porous fillings d thereof into the space of the jar around the outside of the hollow electrode. In order to maintain this difference of level means are provided for withdrawing part of the electrolyte from the jar to a supply tank F, from which it is returned into the hollow positive electrodes.

Storage Battery Plate.—Lamar Lyndon, 852,569, May 7, 1907. Application filed June 3, 1905.

The object is to provide an envelope for storage battery plates through which electrolyte may pass freely, while it is impervious to solid material, even if in a very fine divided state, and held in suspension in the solution. Two different diaphragms of porous coarse-grained wood are united at the sides and at the lower edge with hard rubber or celluloid framework, the whole forming a thin box which is slipped over

the plate. If the upper edges of the box be above the surface of the electrolyte it is unnecessary to seal the top.

Storage Battery Electrode.—T. A. Edison, 854,200, May 21, 1907. Application filed March 30, 1905.

This patent relates to a method for making a spongy honeycomb integral mass of metallic cobalt, or cobalt-nickel alloy, for use as electrode in the Edison storage battery. Scales, flakes, films or foils of cobalt or of cobalt-nickel alloy are produced by electro-deposition, and are carefully annealed below the welding temperature in an inert gas such as hydrogen. The two pocket sections of the well-known Edison construction are now engaged together and securely held by crimping the edges of the outer section around the inner section. The upper end of these pockets is left open for the introduction of the material into each pocket. For this purpose a great number of pockets are assembled, and the metallic flakes or foils are introduced into them through a vibrating screen from above. The amount introduced at each operation is carefully regulated and a definite uniform tamping pressure is applied afterwards. When a pocket has been thus loosely filled with conducting films or flakes it is closed at its upper end and introduced within its supporting grid. The latter is now subjected to the welding temperature in a hydrogen atmosphere whereby the flakes are welded together and to the walls of the pockets. As a result, Edison obtains within each pocket a fine, quite soft, pithy, readily compressible sponge of metal or alloy, presenting innumerable cells all connected together. The active material is now introduced within the sponge-like mass by dipping the electrodes successively in a saturated solution of the active material with alternate evaporations, so as to deposit the active material in layers within the many cells.

Battery Grid.—Joseph Bijur, 854,326, May 21, 1907. Application filed Aug. 14, 1906. Assigned to General Storage Battery Co.

The plate consists of a frame with ribs made of antimonial lead, and into the open spaces between frame and ribs are inserted the grids of pure lead for the active material. The grids and the frame are united according to the process of Mr. Bijur, which consists, broadly, in superheating a globule of lead or alloy to a degree at which it is capable of superficially fusing the surfaces it touches and in depositing it in that condition in a suitable place for uniting the parts of the battery plate.

Flexible Connection for Storage Battery.—B. Ford, 854,817, May 28, 1907. Application filed Sept. 24, 1904.

The object is to provide an acid-proof flexible connection for connecting one storage battery with another or with the line, etc. It comprises a conductor with an insulating cover and an enlarged bare end and a non-corrosive lug cast onto the enlarged end and adjacent portions of the cover.

MISCELLANEOUS.

Drying Electric Cables.—W. B. Hale, 851,747, April 30, 1907. Application filed March 12, 1906. Assigned to Western Electric Co.

The common method of drying cables involves the passage of a strong current through the conductors to heat the cable sufficiently to vaporize the moisture. The vapor is then withdrawn by means of an air pump applied to the end of the cable. The present patent refers to a modification in which a potential difference is established between different conductors of the cable sufficient to cause a flow of current through the moisture remaining in the insulation which separates the two conductors, and the moisture is thereby electrolytically decomposed. As decomposition progresses the insulation resistance gradually increases, and the potential difference is raised but not, of course, beyond the dielectric strength of the cable. To send sufficient current through, it may be necessary to temporarily reduce the resistance of the insulation by means of heat, which may be developed either in the conductors of the cable by

electric currents or in the dielectric itself by the application of an alternating e. m. f.

Treament of Fish Oil.—A. de Hemptinne, 852,662, May 7, 1907. Application filed March 17, 1906.

The object is to eliminate the characteristic and disagreeable odor of fish oil and to make at the same time the oil thicker. This is accomplished by submitting the oil to the action of a silent electric discharge in an atmosphere of hydrogen. The hydrogen is not absolutely necessary, but it accelerates the process and renders it more efficient. The hydrogen is fixed by the oil so that at intervals fresh hydrogen is supplied to the apparatus during operation. The thickening of the oil is also due to the conversion of the oil under the influence of the silent discharge. The process is carried out in a revolving drum containing alternately positively and negatively charged cross-sectional plates separated from each other by plates of glass.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Substitute for Charcoal Iron.—R. C. Totten (854,126, May 21, 1907) endeavors to produce from coke or coal iron—that is, pig metal smelted with coke or anthracite coal—a casting iron suitable for the manufacture of chilled castings or the like which have heretofore been made from charcoal iron. For chilled rolls, chilled car-wheels, etc., the use of charcoal iron has been considered necessary on account of the contents of combined carbon. The inventor introduces the combined carbon by means of spiegeleisen, which contains a large proportion of combined carbon, while the manganese present aids the combined carbon in importing chilling properties to the iron. His cast metal consists of coke or coal-iron and spiegeleisen, the composition containing at least ½ per cent of combined carbon and manganese at least 1 per cent in excess of the combined carbon. For example, if the combined carbon present is 1 per cent the manganese will be 2 per cent or over. The casting metal so produced can be made at lower cost than the charcoal pig iron usually employed for the making of such castings, as the cost of the ordinary gray coke or coal iron is much lower than the cost of charcoal iron, and though the cost of spiegeleisen is higher than that of charcoal iron the small proportion usually employed does not materially increase the cost of the casting produced, the actual cost of the composition being less than the ordinary charcoal pig iron.

Ferro-Molybdenum.—H. W. C. Annable, of the Ferro-Alloys Syndicate, of London (852,920, May 7, 1907), patents the following process for producing ferro-molybdenum from molybdenite. The latter is an ore which consists essentially of sulphide of molybdenum. It is ground and mixed with sodium carbonate or sodium hydrate or a mixture of both, and the mixture is heated to a temperature just above the melting point in a reverberatory furnace; the fire gases and products of combustion carrying an excess of oxygen. The whole bath is uniformly heated to a temperature just above the melting point, and the effect of the excess of oxygen in the gases is to oxidize the sulphur and molybdenum and to cause them to combine with the alkali. The charge thereby becomes a mixture of sulphate of sodium, molybdate of sodium and free sodium hydroxide mixed with the unattacked portion of the ore. The charge after having been withdrawn from the furnace is crushed and thrown into hot water, which dissolves the sulphate of sodium, the free sodium hydroxide and the molybdate of sodium. From this hot, strong solution the molybdenum is precipitated by means of a solution of an iron salt, such as ferric chloride, ferric sulphate, ferrous chloride, ferrous sulphate or mixture of these. The precipitate consists of molybdate of iron which will be free from sulphur if the process is carefully carried out. The molybdate of iron is dried and re-

duced to ferro-molybdenum by either of the following two ways: The first method is to heat the molybdate of iron to a low red heat in a furnace without admixture of carbon and then reduce it to ferro-molybdenum by a current of a suitable gas, such as coal, producer or water gas, the heat being maintained until the gas evolved ceases to contain products of deoxidation. The ferro-molybdenum is then allowed to cool in contact with the reducing gas. The second method consists in mixing the molybdate of iron with sufficient pure oxide of iron to produce after reduction a ferro-molybdenum which is fusible at a white heat (from 1,300° to 1,400° C.), and with sufficient carbonaceous matter to reduce the oxides. This process may be carried out in an apparatus containing two refractory receptacles, one above the other, and heated to white heat. The upper receptacle contains the mixture under treatment. From a hole in its bottom the reduced ferro-molybdenum drops into the lower receptacle which contains oxide of iron. The ferro-molybdenum percolates through the iron oxide and is obtained practically free from carbon.

ZINC.

Reduction Furnace.—The rotary motion which is such a characteristic feature of many inventions of C. G. P. De Laval, of steam turbine and cream separator fame, is found in the same inventor's zinc reduction furnace shown in Fig. 1. The zinc ore together with materials necessary for carrying out the reactions is introduced into the furnace chamber in which the charge is subjected to a rapid rotation by means of a rapidly rotating gas or air current. If the zinc ore consists of unroasted sulphide of zinc the charge is composed of sulphide of zinc, carbon and iron ore, whereas the gas current consists of carbon monoxide or air, mixed with carbon in a proportion so as to form carbon monoxide in the furnace chamber. If the sulphide of zinc is roasted, iron ore need not be added. If the material to be treated consists of zinc oxide, carbon is added for its reduction, whereby the gas current
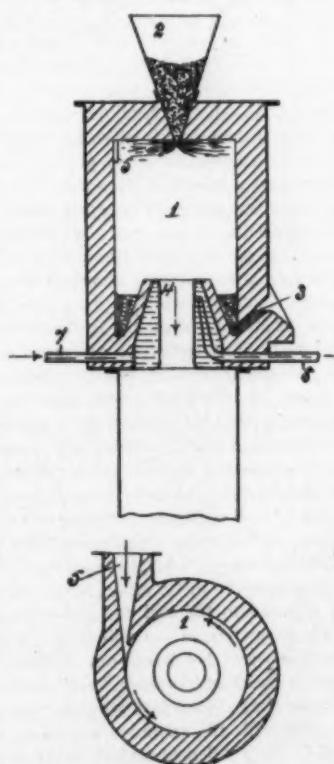

FIG. I.—ZINC FURNACE.

preferably consists of carbon monoxide to avoid reoxidation of the zinc. If zinc oxide is to be produced an air current is employed for obtaining the oxidation. The charge is introduced continually and uniformly in the upper part of the furnace chamber, for instance, through the hopper 2, whereas, simultaneously carbon monoxide or air mixed with carbon in a proportion so as to form carbon monoxide within the furnace chamber is introduced tangentially and with great velocity by pressure or suction through the pipe 5. Owing to the tangential direction in which the air or gas current is introduced the current will follow the circular

furnace wall and is thus brought into a rapid rotation, which is also imparted to the charge introduced. In or near the center of the bottom of the furnace chamber is an outlet 4 for the gases developed during the process. The gases will flow in a spiral direction during their way from the furnace wall, which they follow at the inlet, to the outlet in or near the central line of the furnace. The charge on the contrary is subjected to the centrifugal force during the rotation and moves from the central line of the furnace to the circumference of the same, during which motion the chemical processes are carried out. The charge and air or gas current will therefore move in opposite directions toward one another, owing to which the processes are carried out rapidly and completely. The crude ore and slag produced during the process gather on the furnace wall and flow down to the lower part of the furnace, from which they are drawn off through the outlet 3. The developed zinc gases or the zinc oxide fume follow the gases out through the outlet 4, and are condensed or gather in any convenient manner. In the construction shown on the drawing the outlet is formed with a hollow wall and which is cooled by means of a water current circulating through the pipes 7 and 8.

Filling Zinc Retorts.—J. D. James (851,668, April 30, 1907) proposes a mechanical method of filling zinc retorts by blowing the zinc ore, etc., with the aid of a jet of "fluid," under strong pressure, into the retorts, the jet being of such force as to pack the charge firmly and evenly within the whole cross-section of the retort.

PRECIOUS METALS.

Continuous Boiling-Out Still.—J. T. Ludlow and D. Mosher (853,986, May 21, 1907) patent details of construction of an apparatus for use in the ammonia-cyanide process of treating copper, nickel or zinc ores containing precious metals. The idea is first to transform the metals such as copper, nickel or zinc, present in whatever form in the ore, into a condition soluble in ammonia solutions of varying strengths; leaching such ammonia, copper, nickel or zinc solutions from the ore by known methods, and under conditions which will, as much as possible, prevent loss of ammonia; then by boiling the ammonia solution of metal hydroxide, carbonate or sulphate the metal is precipitated as oxide at the boiling point of water, and is thereby practically rendered anhydrous. The ammonia passes over as vapor to be reabsorbed by cold water or cold boiled out waste solution for use with slight loss over and over again. The apparatus described in the present patent is intended to accomplish the metal oxide precipitation and ammonia recovery in an economical and continuous manner. The chief feature is a boiling-out still, having such connections that during the process of boiling out to liberate the ammonia from the solution and to precipitate the metal oxide, the metal oxide ammonia solution is supplied to the still and the waste hot boiled-out solution is discharged from the still in a continuous flow or operation. The waste hot boiled-out solution from the still passes through a "heat interchanger," and gives up its heat to the incoming metal oxide solution which passes through the interchanger to the still; the ammonia gas meanwhile passing from the still to the condenser and absorber to be returned to the supply of metal solvent for use over and over again.

ALLOYS.

Copper Zinc Alloy.—G. E. Buttenshaw (854,462, May 21, 1907) patents an alloy suitable for use in the construction of marine engines, pumps, sea valves, torpedo tubes and the like, which are brought into contact with salt water, and which shall not be liable to oxidize or set up galvanic action in the presence of iron and steel. The alloy consists of the following metals in the stated approximate proportions by weight: Copper 40 to 43.19 per cent, zinc 41 to 43.86 per cent, nickel 10 to 10.20 per cent, lead 1 to 3.5 per cent, phosphor tin 1 per cent, aluminium 0.15 per cent.

ASSAYING.

Pouring Mould.—The object of the construction of a pouring mould patented by Mr. John J. Bailey (850,811, April 16, 1907) is to facilitate the separation of the metallic portion of the contents of the mould from the slag. The construction is shown in Fig. 2, the upper diaphragm being a top plan and the lower one a longitudinal section. When in use the body of the mould rests on the base plate 6. The body of the mould is
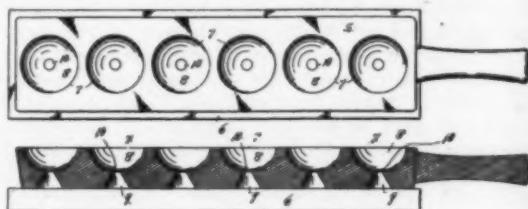
FIG. 2.—POURING MOLD.

composed of a series of receptacles 7, each of which consists of two compartments, 8 and 9, of which 8 is cup-shaped and 9 cone-shaped; the two compartments communicate with each other through a small orifice 10. After the ore from which the values are to be extracted has been mixed with the necessary flux and reduced to a molten condition it is poured into the receptacle 7. The metallic portion to be separated from the gangue is heavier and passes downwardly into compartment 9, while the lighter gangue occupies the compartment 8. As soon as the contents of the receptacle become cold it is only necessary to tap the contents of 8 with a hammer in order to cause the metallic contents of 9 to break off and drop out of its compartment. In this way more nearly an exact separation of the metal from the gangue is effected than can be accomplished when the molten mass is poured into a single compartment.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals.

ELECTRIC FURNACE.

Electric Furnace Reactions Under High Gaseous Pressures.—A brief summary has just been published in the *Proceedings* of the Royal Society of the investigations of Dr. R. S. Hutton and Mr. J. E. Petavel with their high-pressure electric furnace. (See *Electrochemical Industry*, 1903, I., 244-245.) The following will serve as an indication of the contents of the paper which it is hoped will soon appear in extenso. Two steel chambers of 20 and 2 liters capacity, respectively, provided with valves, windows and insulated electrode holders have been constructed and employed at working pressures up to 200 atmospheres. Inside these pressure vessels any desired arrangement for arc or resistance heating is mounted. Apart from the influence of pressure, which was the primary object of the investigation, special attention was paid to the effect of the nature of the gaseous atmosphere upon the reactions. Some measurements were made of the electrical constants of carbon and metal arcs in different gases at high pressures and the rate of oxidation of heated metals was also considered. With a charge of 10 kilos. of lime and carbon the preparation of calcium carbide was studied in atmospheres of carbon monoxide, coal gas and hydrogen under reduced and high pressures. Contrary to expectation no unfavorable influence of carbon monoxide upon the yield was noticeable, the back reaction being limited to the surface. Silica fused under pressure exhibits a marked decrease in vaporization but no appreciable increase in fluidity and transparency. The production of carborundum under pressure is much limited owing to

this decreased volatility of silica. The authors as a result of a long detailed investigation of the reduction of alumina, conclude that this oxide is reducible by carbon at all temperatures above the melting point, but the metal is set free in the form of vapor and can only be collected if it be protected from reaction with carbon monoxide. Having overcome the difficulties of maintaining an electric arc in highly compressed air it is shown that the production of oxides of nitrogen exhibits an increased efficiency attributable to pressure.

COKE.

The Determination of the Quality of Coke from its Appearance.—The basis for determining the quality of coke as a rule is, of course, a chemical analysis, though it is a matter which is very frequently left to judgment by the eye, and it is possible for experienced observers to obtain considerable accuracy. In *Glückauf* of March 9, 1907, Mr. Thau details a series of observations, based upon analytical data, of the quality of coke when judged by the eye only. The author concludes by summarizing the following characteristics for coke with a high content of ash: (1) Impurities consisting of incombustible substances in the fracture; (2) Dark, sandy appearance, without a great abundance of pores; (3) Exceptionally high weight; (4) The edges of the pores appear with metallic luster in the fracture. The following are characteristics for a high content of volatile ingredients: (1) The coke falls without sound when dropped upon a hard surface; (2) It has a black appearance without luster; (3) It contains small blue-black spots in the fracture, due to uncoked coal; (4) It appears in thick pieces which break apart easily; (5) The interior of the pores is deep black and the edges have a tarry luster.

It is easy to ascertain a high content of water if a small piece of coke is knocked off and the pores are seen to be filled with water under the magnifying glass. It is also possible to notice a cold feeling in the hand when a piece of coke is gripped firmly. If the content of water amounts up to 6 per cent it is absorbed by the pores, so that it is hardly or scarcely noticeable. The analysis for ascertaining the sulphur content of coke as carried out by the author is as follows: 11.5 grams of pulverized sodium peroxide and 0.7 grams of finely powdered coke, or 16 grams sodium peroxide and 0.7 grams of coal are weighed out into a steel, or, better, a nickel crucible of about 50 cc. contents. Both ingredients are mixed thoroughly and the crucible is put upon a small tripod into a beaker in such a manner that there is 1 cm. distance between the bottom of the crucible and that of the glass. The beaker is then filled with distilled water, so that the crucible is standing in the water up to about its middle. In the cover of the crucible there is a small hole, through which an incandescent wire is introduced in order to ignite the contents of the crucible. After about three minutes the crucible is put on its side so that the contents can dissolve. After that the crucible lid and tripod are well washed off and removed from the beaker. So much hydrochloric acid is then added that the solution is just acid. This can be recognized when the acid is added slowly by the appearance of a bright green color and a complete coloring up of the liquid. The solution is then boiled and a few drops of ammonia barely in excess are added, and then 15 cc. of barium chromate (solution, 23 grams barium chromate, 80 cc. concentrated hydrochloric acid, 920 cc. distilled water). At this point one has to be sure that ammonia is in excess, and that the solution is boiled until no smell of ammonia is recognizable, and no longer, and until the solution has been concentrated to a quantity suitable to titration. The solution is then filtered, the precipitate boiled with water, and 1 gram of potassium iodide is added to the filtrate. It is then cooled off to 30° C., 5 cc. of hydrochloric acid are added and a little starch as indicator, and the solution is titrated with a 1/10 normal solution of sodium thiosulphate. The main point in this analysis, of which several can be made in an hour, are two, namely: (1) The solution must be very well filtered

—the filtrate must be absolutely clear; (2) The preparation of the barium chromate solution is of great importance because the barium chromate which can be bought in the trade contains mostly an excess of barium chloride or of potassium chromate. It is therefore better to make this preparation oneself and to wash it well, inasmuch as a small excess of either one of these substances influences the result of the analysis.

Formation of Prussian Blue in the Ammonium Sulphate from Coke-Oven By-Products.—Many coke-oven plants experience considerable trouble on account of the blue coloration of the ammonium sulphate, which, though it is not of any consequence as far as the quality of the salt is concerned, yet affects the selling price to a great extent, as the blue-colored salt is not as easily disposed of as the pure white. Much trouble has been experienced in overcoming this discoloration of the salt, and some of the plants turn out hardly anything else but salt of this description. Mr. Thau, in *Glückauf*, of Jan. 26, 1907, investigates the causes of the formation of this blue salt, which is due to the formation of Prussian blue. This Prussian blue makes its appearance wherever cyanogen from ammoniacal gases or from the condensed ammonia water is separated out and forms a compound with the iron of the walls of the tubes or apparatus. This happens especially in such cases in which an excess of crude ammonia gas is employed for cooling purposes. It happens in the rarest cases that the distillate is still blue in the distillation apparatus unless very cold ammonia water is introduced. In order to prevent this, therefore, a good preliminary heating of the ammonia water is a prime requisite. The place where the Prussian blue compound is formed in most cases is at the junction of the pipe between the distillation apparatus and the saturator. In order to prevent its cooling the pipes should be well insulated, and should rise more towards the saturator so that any condensed water which may be present can flow back into the apparatus. The valves should also be located as close as possible to the junction points of the pipes so that it is not necessary to keep steam in long lengths of pipe, and thus give it opportunity for distilling. A further place where the formation of the blue cyanogen compound takes place is the draw-off pipe line for the cyanogen vapors of the saturator. If any or all of these causes are seemingly excluded the formation of the discoloring compound is evidently due to faulty manipulation of the apparatus. It should be such that in no case the ammonia vapor becomes too cold, not below 100° C., as an excess of crude ammonia gas can already cause the formation of Prussian blue in the pipe line below a temperature of 980° C. The author gives the following rules for the utilization of the blue salt if it has been formed. Larger quantities of this salt should be kept separate and it should not be mixed with the white salt, inasmuch as 1 ton of blue salt contains enough coloring matter to color intensely 20 tons of white salt. Smaller amounts should be dissolved in hot water, and this solution should be added to the bath, or about 10 to 20 kg. of salt should be added in a solid form to every fresh bath.

PRECIOUS METALS.

The Moore and Butters Filters.—In the *Mining and Scientific Press* for April 20, 1907, the arguments pro and con in regard to the Moore and Butters types of filters which have been mentioned repeatedly in the Digest are considered, and Mr. E. H. Nutter, assistant general manager of the Liberty Bell Mill at Telluride, Col., gives a brief résumé of the particular problems of these systems of working. Mr. Nutter thinks that the contention that the sum of advantages lies with the Butters-Cassel process is based on insufficient grounds and is incorrect, and that for small plants there is little to choose between the two processes. For plants of medium size with a treatment capacity of from 100 to 200 tons per day, where a good hillside site is available, which would make a gravity discharge for the Butters filter-boxes possible, the operating expenses of the two processes should be about the same, the

first cost being in favor of the Moore plant. Where, however, large tonnages are to be treated or where such a side-hill site cannot be had, the advantages of the Moore process, which consist in its lower power requirements, its greater compactness, its lower first cost and the higher time efficiency of the filtering units, become of increasing importance. In Mr. Nutter's opinion, they outweigh whatever difference in repairs there may be in favor of the stationary filter. He thinks that in light of the experience so far obtained with the Moore process, there is no question but that rational design which takes account of all possible contingencies whose quantitative effects have been proved important will eliminate, practically, the faults that have so far developed. Comparing the Moore and Butters processes the operating labor is the same for both systems. The power requirements are less for the Moore process, and the technical efficiencies are about equal. The first cost of the Moore plant is less, and therefore the amortization and interest charges are also less. The royalty charges should be the same. Mr. Nutter thinks that, undoubtedly, the Butters process has so far made the best showing for filter repair expenses, but it seems probable that the new filters at the Liberty Bell will compare favorably with the Butters filters.

LEAD.

Silver-Lead Smelting.—The views on silver-lead smelting practice of the late T. S. Austin, the well-known metallurgist, contained in letters to his brother, Prof. L. S. Austin, are published by the latter in *Mining and Scientific Press.* In regard to furnace running and conditions in the issue of March 16, Mr. Austin remarks that the metallurgist's skill and judgment come in "the running on the ragged edge," in order to get fast running of the furnaces and avoid too large loss of lead in the slag. The three furnace conditions are the following: (1) Ideal working. The slag assay gives medium results for lead, say, 1 to 1.2 per cent, the slag is fluid and hot, the speed of the furnace high, the smoke or fume escaping at the throat light in volume, color gray or dark, base bullion output good. (2) Under reduction. The slag is higher in lead, say, 1.2 up to 2 or even 3 per cent or more, the slag fluid but cold and red, looking heavy, the speed very high, the smoke thick and much in volume, with a grayish-white color, the base bullion output bad. To correct this condition there is needed extra fuel, scrap iron or some other reducing agent, and even a moderate lowering of blast. (3) Over reduction. The slag is low in lead, say, only a few tenths of 1 per cent, the speed much reduced and the furnace tightening, the slag slow-running but hot, the furnace top hot with white smoke when the fire mounts too near the surface, and very little at all when it is quenched back. The base bullion output is good but the crucible is liable to get sticky. This condition is to be corrected by cutting down the fuel. With high speed there should also be but little trouble in keeping the fore-hearth or settler open and in good condition, especially if one has much matte. Mr. Austin was of the opinion that fast running tends to increase the silver in the slag under certain circumstances, namely, when the silver and the lead are not allied in the minerals that compose the smelting mixture, that is, if the silver is in a silicious ore on the one side and the lead in a low-grade carbonate on the other side. In this case fast running will induce high silver slag, because the lead and silver will not have time to come into intimate contact and mixture. If the silver, however, is in a mineral together with lead, as an argentiferous galena, or with lead and copper as gray copper ore (tetrahedrite), or even as a sulphide with other base sulphides, it will be taken up by the lead much more rapidly and faster running will be permissible. One could readily conceive of a condition of affairs when almost any speed, within reason, would not seriously affect silver loss in the slag; thus the lead ores might be largely good grade argentiferous galena and carbonate mixtures, the silver ores medium or even high-grade quartz ores

carrying the silver associated with lead, copper and iron sulphides. Considerable quantities of roast product, fused or sintered, might also be attainable, and roasted matte, containing copper, be largely used. In regard to the amount of blast, Mr. Austin holds that generally 15 ounces will give all that can be desired on an average coarse ore; speed can be gotten at that pressure by cutting down rather than by raising blast. The furnace should be driven all one can up to the point of hot top, avoiding always that objectionable feature.

American Museum of Security.

In our February issue, page 37, we discussed the exhibition of safety devices and in general of objects relating to industrial safety and industrial hygiene, held at that time at the Museum of Natural History in New York. This was the first exhibition of its kind and was held under the auspices of the American Institute of Social Service.

This first exhibition was such a success that the establishment of a permanent Museum of Security is now being taken into consideration. With the purpose of arranging the preliminary plan a conference was held on March 22, at which numerous editors and publicists of New York City were present. It was stated that even in New York City alone, taking the statistics for certain years, an average of from nine to thirteen persons met with violent deaths each day. Most of the accidents to which these deaths can be attributed are preventable by the use of proper safety devices.

The plan is to establish the permanent museum of approved safety devices at New York City, to which the public will have free access at all times. It is estimated that about $25,000 will be needed as the initial fund. About $1,500 has already been raised for this purpose, $1,000 of which has been pledged by the Non-Explosive Safety Naphtha Container Co., of New York City. The *Scientific American* has pledged the fund required for the annual award of a gold medal for the best safety device. An advisory committee was appointed, consisting of the editors of the leading technical and trade journals.

A meeting of this advisory committee was held on April 11, at which Mr. Charles Kirchhoff, of *Iron Age*, was elected chairman and Mr. T. C. Martin, of *Electrical World*, vice-chairman. A letter was read from Mr. Francis H. Richards offering a gold medal, to be awarded at the next exhibition, for the best invention shown relating to automobiles and motor boats. It was also announced that Dr. L. L. Seaman had offered an annual prize of $100 for the best essay on the subject of safeguarding life, the essay to be a study of existing conditions and methods for their improvements. Various committees were appointed to further the program, as outlined above, and it is hoped that the American Museum of Security will become a reality before the end of this year.

Rev. Dr. Josiah Strong and Dr. W. H. Tolman are the enthusiastic leaders of this movement.

A Modern Electrically-Operated Copper Converter.

By G. E. SHIPLEY.

One of the most interesting and modern converter plants is now being erected by the Orford Copper Co. at Constable Hook, N. J., under the supervision of Mr. E. Franki, chief engineer. All of the machinery installed there has been designed to meet the most exacting conditions.

The converter equipment of the Orford Copper Co's new plant consists of three electrically-operated stands and nine shells 84 inches diameter by 126 inches long.

Shells.—Referring to the accompanying illustration it will be noticed that the shell has a peculiar shape at the top half,

which is not found in other converters. The bottom half is 84 inches diameter, and from the center up to the joint both sides of the shell are formed in a tangent to a width at the top of about 6 feet 8 inches. The object of this is to do away with the unnecessary curvature above the center line and permit of a more secure lining being formed therein.

The parting joint between the bottom half and top half is considerably higher than in other designs, the idea being to keep this just as high as possible and away from the extreme action of the molten copper; for it is a fact that in practically all of the barrel converters, with the exception of those at the Washoe plant, this joint is only carried a small distance above the center line, and since at this joint there is no chance to ram the lining, it is only possible to form the joint with an adobe mixture. The result is that under these conditions the joint is eaten away very rapidly by the molten matte. In our new type of converter, however, that particular and vital defect has been overcome by raising the joint between the bottom and top shell.

The bottom section of the shell is made of flange steel plate, and at both ends it is rigidly secured to a solid cast steel head provided with a riding ring completely encircling the head.

Each head is spherical in shape and re-enforced with six heavy ribs to reduce expansion and contraction due to the in-

ELECTRICALLY OPERATED COPPER CONVERTER.

tense heat. In a great many converters, which have been designed without the ribs, much trouble has been caused and a great deal of expense incurred in fitting new shells into stands which had the air connections bolted to the heads.

For lifting the shells, there is riveted at the joint a solid cast steel re-enforcing plate on the lower half, which has cast integral with it one heavy lug on each end of each plate, making four lifting lugs in all. These re-enforcing plates or angles are also arranged for bolting on the top half by three extra heavy bolts on each side.

The top half is slightly different from what is shown by the cut, inasmuch as there is furnished an independent pouring nose which is bolted to the cast steel top and can be renewed from time to time as it is eaten away.

In some cases a great many operators object to the short cast iron pouring nose, for the reason that accretions form very rapidly on the flanges, and they prefer to have a plain nose which can be re-enforced with steel plate when eaten away. The shape of this top, as well as the bottom, in this particular converter is practically the same as the converters in use at Anaconda, and is a peculiar shape which has proven to give a longer life to the lining.

The reader will note, by referring to the cut, that the wind-box is made rectangular in shape and consists of a plain cast-ing that lies close to the shell and underneath the riding ring, thus permitting the shells to make a complete revolution and

thereby do away with the stop which it has been customary to place on a great many riding rings in order to protect the wind-box and prevent the shell from turning too far.

With the old stop arrangement it was necessary to be very careful in turning, otherwise an operator would throw the shells off the stands and thus cause a serious accident.

Another feature of the self-contained wind-box is that it does away with the long flange and cover that has always been used where the air valves of tuyeres were fitted on the inside of the wind-box.

It is well known that there is always a great loss of air through the joint in the long cover ordinarily used, because the expansion and contraction and the hard service to which con-verters are subjected in a very short time ruins the joint.

Individual Tuyeres.—On this particular converter there are fitted fourteen Repath individual tuyeres, and each tuyere is fitted with a Dyblie ball valve.

Each tuyere is secured to the wind-box by swing bolts, and the discharge end, which is at right angles to the inlet, pro-jects several inches inside the shell and through a cast steel stuffing box which is secured to the shell. This stuffing box is bored out to suit the projection on the tuyere and ar-ranged for holding asbestos packing, while the projection is sufficient so that a lining of brick can be fitted securely around the end and thus prevent air leaks.

Each tuyere is arranged so that the ball valve and its seat are self contained, and the valve can be taken out and replaced by another very rapidly. The pipe distance piece is also inde-pendent and very accessible. It will, therefore, be seen that with this individual arrangement of tuyeres it is only neces-sary to disconnect two swing bolts and put out the tuyeres. It is not necessary, when replacing a single defective pipe-distance piece, to disconnect a long and heavy cover and have the great difficulty of trying to make a joint on a long and warped casting.

The general opinion of many will probably be that accretions will form between the wind-box, tuyeres and shell, and to such an extent that it will not be possible to get at the swing bolts that fasten the tuyeres to wind-box; but such is not the case, because to obviate this there is an angle on top of the wind-box running the full length and riveted to shell.

It has been demonstrated that the ball valve is more satis-factory than the roller valve, because the spherical shape of the ball adjusts itself to the valve seat and there is no chance for grooves forming, due to the hard usage and constant pounding of the tuyere punching bar.

Air Connection.—On the air end of each shell the cast steel head is arranged to receive the end of the wind-box, which is fitted with a ball-joint concave flange, and receives the station-ary air nipple of the patented blast connection.

This joint is especially adapted to converters and air joints where it is not possible to bring flanges in line, due to the difference in centers of shells, which are bound to become dis-torted and lose part of their shape after hard usage. This con-nection consists of a cast iron T, having the horizontal cylin-der fitted with a ball joint and piston. When the shell is moved into position the lever is pushed forward, and this moves the nipple into the concave flange on the head. The air is then turned on and the pressure upon the piston holds the joint rigidly in place.

This joint is far superior to the old method of matching flanges and has proved to be a great labor-saving device around converting plants.

Electrically-Operated Stands.—For turning the shell each stand built for the Orford Copper Co. is provided with a 30-hp. Allis-Chalmers direct-current, variable speed, multi-polar, enclosed type series wound motor for 110 volts and 600 revolutions per minute, which is geared up to the main drive shaft so that the maximum speed of shell is reduced to 1½ revolutions per minute. (In plants where alternating current is available, induction motors are, of course, used to turn the

converters, and for this service they offer a number of special advantages.)

For regulating the turning speed of the converter shells there is a suitable controller, arranged with a liberal number of speeds in each direction.

The motor shaft is connected to the worm shaft by a coupling, which also acts as a brake wheel for the solenoid brake, and on this extension is keyed a single-thread steel Hindley worm that runs in an oil bath and meshes with a solid worm wheel, thus making the first reduction. On the worm wheel shaft is secured a cast steel pinion which in turn transmits its energy to a cast steel gear, both having shrouded teeth and designed for taking care of severe shocks.

The gear is keyed to a hollow steel shaft, which has fitted to the driving end a universal coupling, arranged so that the shells will lie true on the rollers and at the same time the drive will adjust itself to suit the alignment, and thus avoid any undue strains on the drive shaft.

On the head of the shell is a groove, which matches a tongue on the universal drive, and when placing the shell in position on the stand the motor is turned around until the tongue is vertical when the shell is placed, and there is clearance enough on each side of the tongue for keys, which are tapped into place by a light hammer, thus holding the shell rigid to the universal connection.

In some converters this groove on the shell has only sufficient clearance to allow the shell to drop over the tongue and no provision is made for using the keys, in which case there is a chance for a back lash, due to the clearance and the fact that the motor will have a chance to accelerate before it picks up the shell, and the result is a severe shock which is very detrimental to the train of gears.

Motors for turning converters have very severe work to perform, and in this case the maximum starting torque of motor is several times greater than the full-load torque. All possible chance of the shells turning when the current is turned off is prevented by an automatic braking device.

The complete "A" frame for supporting the motor and carrying the gears consists of a massive box frame casting with all bearings liberally proportioned and lined with the very best babbitt.

Housing.—There is a sheet steel housing for each frame, which covers all the driving gear and motor complete, as shown in dotted lines on the cut, to prevent dirt from getting into the operating parts.

Pouring Spoon.—A very important detail in connection with the pouring operation of converting is to obviate spatter or spill of the copper upon the floor, and to prevent this there is a Bennetts pouring spoon, hung on a steel arm on one side of the roller stand, with the arm so arranged that the spoon can be adjusted to suit the pour of copper from the shell and the position of the moulds which rest on the truck directly underneath.

General.—Another important detail which is not shown in the cut is a mould car mover, which is attached to a slide on the inside of the roller stand next to frame, and this mover is operated by an air cylinder, which in turn transmits its power through a piston rod to a guide which has an arm that can be dropped into place on a mould car and thus push the car along into the proper position to suit the moulds.

The three stands are operated from a pulpit which is located on the opposite end of building and off to one side, and this is where the controller, air blast and mould car operating levers for all three stands are placed, so that they may be manipulated by one operator.

It is safe to say that the following data is close enough for practical estimating purposes:

	Tons.
Weight of shell	13
Weight of lining	28
Total	41

Cubic feet of concrete in foundation 960.
Capacity of charge 40 per cent matte.

First charge (new lining)	5¼
Average charge (new lining)	6¼
Maximum charge	9 to 10

Blowing time—

	Minutes.
First skimming for slag	45
Second skimming for slag	60
To blister copper	135
Total	240 = 4 hours.

Air blast pressure 10 to 12 pounds.

Therefore, assuming six charges per stand per 24 hours and 26 working days per month, the capacity of each 84-inch x 126-inch converter will be about 780,000 pounds of copper per month. Of course, this will all depend upon the matte and the conditions under which the converter is operating. In some cases this capacity could be increased 30 per cent where they are converting under ideal conditions, whereas in others the above capacity would be high for badly arranged plants.

Mr. C. H. Repath, engineer of the Anaconda Copper Mining Co.; Mr. F. E. Marcy, of Salt Lake; Mr. J. A. Dyblie and Mr. B. H. Bennetts all deserve special mention for the many special features which are incorporated in this machine.

Long-Scale Switchboard Instruments.

Recognizing the need there is for switchboard instruments well suited for use with generators of large capacity and where readings must be made at a considerable distance from the switchboard the American Instrument Co., of Newark, N. J., has recently placed on the market a new long-scale instrument which is shown in the accompanying illustrations.

These instruments are provided with scales approximately 14 inches long, or twice the length of the usual large-size round-pattern instrument. Owing to this there is ample room

FIG. 1.—LONG-SCALE SWITCHBOARD VOLTMETER.

for large divisions and large figures, which, together with the unique method of marking the scales (clearly shown in Fig. 1) make them extremely clear and legible. For this reason they are particularly well adapted for use with generators of capacities running up to several thousand amperes and also where it is essential that accurate readings be made from a considerable distance.

Perhaps the most unique feature of these instruments is the

method of mounting them on the switchboard. When an instrument with a long-scale as described above is mounted entirely on the front of the board it projects a considerable distance, and is more or less in the way, while if the same instrument is mounted flush it requires cutting a large irregular shaped hole, which weakens the panel very materially. The way in which this new instrument is constructed entirely obviates both of these difficulties. It projects less than 2 inches from the front of the board and at the same time only requires a circular hole 6⅝ inches in diameter to be cut in it. Thus they are easy to mount, the panel is not unduly weakened and they offer all the advantages of the flush-type instruments. Very satisfactory illumination may be obtained by means of a lamp and bracket mounted over the instrument.

Fig. 2 shows the construction of the case which allows for this unusual method of mounting. The instrument proper is mounted on a circular box as shown, and this projects through the board while the shallow portion of the case contains the scale and lies flat against the front of the switchboard. Altogether, the finished appearance of these instruments is particularly attractive and adds materially to the distinctive character of any switchboard.

The internal construction of these new type-3 instruments conforms strictly to the high grade of excellence which the American Instrument Co. has already established in its round pattern and portable instruments. The magnets are of the very best magnet steel, aged and magnetized according to the latest and most approved methods. The mechanical construction of the moving coil, its mounting, etc., are extremely simple and rugged, so that they are well adapted for the hard service which is bound to come to any switchboard instrument.

Ammeters of this new type are arranged to operate in connection with the regular interchangeable switchboard shunts which are used with round-pattern switchboard instruments. These shunts are adjusted to give a uniform drop of exactly 50 milli-volts on full load. Also the instrument, together with its leads, is adjusted to have an exact resistance of 1 ohm and to give full deflection on 50 milli-volts. Thus it is clear that any shunt of any capacity can be used with any instrument and any pair of leads, and correct results will be obtained. This feature is of greatest advantage, as it allows the use of any number of shunts of any capacity on one indicating instrument, the only requirement being that a suitable two-pole switch of negligible resistance be inserted in the leads between the instrument and shunts. Also should an instrument be disabled through accident it can be returned to the factory for repairs and properly adjusted without disturbing the shunt at all; and while it is out of commission another "American" ammeter, whether of the same or different type, may be used and correct readings obtained, when the proper multiplier is used to make the scale values agree with the shunt capacity.

These long-scale voltmeters in common with all "American" voltmeters whether of switchboard or portable types are adjusted to have a uniform resistance of exactly 100 ohms per volt, so that a 150-volt instrument has just 15,000 ohms total resistance and a 300-volt instrument exactly 30,000 ohms resistance and so on. This uniformity makes it possible to use multipliers interchangeably should they be required, and also

FIG. 2.—SIDE VIEW OF LONG-SCALE SWITCHBOARD VOLTMETER.

adapts the instrument for measuring insulation resistance and grounds most satisfactorily.

Where generators of large capacity are used there will naturally be large currents flowing in the bus-bars, which will set up magnetic influences which effect the readings of the ordinary instrument. The American Instrument Co's long-scale instruments as well as its other switchboard round-pattern instruments are, however, provided with soft-drawn sheet steel cases, which provide a most efficient magnetic shield for the internal parts, so that powerful external fields do not influence the indications. As these cases are drawn into shape the material must be of uniform softness throughout. In consequence of this there is practically no danger of the cases becoming permanently magnetized as they do when cast iron is used. In addition to the shielding quality of these cases they are so designed that where parts come together there is ample bearing service, which effectively prevents the entrance of dust.

Mr. James G. Biddle, 1114 Chestnut Street, Philadelphia, is general sales agent for the American Instrument Co.

A Non-Stop Run.

Electrical generators have become such a standard product that attention is seldom called to that thoroughness of design and construction which results in such a record of reliability as that shown in the following statement concerning a 150-kw., three-phase, belt-driven alternator built by the General Electric Co. This generator ran more than four years, 24 hours a day, with a single stop of 15 minutes, due to a defective pulley. The details of this performance are given by Mr. Rhodes,

ALTERNATOR HAVING MADE A NON-STOP RUN OF MORE THAN FOUR YEARS.

assistant manager of the United States Smelting Co., West Jordan, Utah, as follows:

"The generator was received about June 1, 1902. Put in service Oct. 15 for 11 hours per day until Nov. 9, when 24 hours per day service was required. Jan. 25, 1904, shortly after noon, the paper pulley on exciter went to pieces. A cast iron pulley being on hand a shut-down of 15 minutes was recorded. From June 13 to 18, 1904, the switchboard was moved, and all feeder circuits were connected directly on the machine without switches or fuses by means of jumpers without a single mishap to cause a shut-down. Last Fall one of the screws worked out of one of the split oil rings on pulley end. Not being able to shut down we ran along with the remaining one till March 28, 1907, when the machine was shut down for three days, thoroughly cleaned out, new oil put in bearings, collector rings turned true, the broken oil ring fixed, and service commenced as usual, vacouline oil being used during this run.

The alternator is belt-driven, and an engine located at either side with belt attached in case of emergency. Bearing in mind that this machine carries a continuous overload of 25 to 60 per cent its record is truly wonderful."

Notes.

Electric Power from Blast Furnace Gases.—From a European exchange we note that La Société des Forges d'Eich is installing at Dommeldingden, in Luxemburg, a central station which will be worked by blast furnace gas. A contract has been made for a term of fifteen years with the town of Luxemburg for the supply, for lighting and other industrial purposes, of all the energy over and above that necessary for the society's own needs. The price is fixed at 1.4 cents per kilowatt-hour for the first 2,000,000 kw-hours and 1.2 cents per kilowatt-hour after. The cost of generation is estimated to be 0.5 cent.

Zinc Dust in Cement.—It has been known for some time that a cement made out of certain oils and zinc dust possesses the useful property of becoming exceedingly firm and adhering closely to iron, steel and other metals when heated to a temperature of 150° C., or even less, if treated for a sufficient length of time. The theory of the nature of zinc dust which Mr. Alfred Sang has given in his article on Sherardizing in our last issue, explains this hardening by the release of the zinc from its peculiar condition, to form a solid without the formality of passing through the liquid stage. In the body of the cement it is protected from oxidation and the zinc becomes mechanically continuous. It is an excellent composition for calking cracks and crevices in metallic objects, for packing joints and for smoothing off the surface of castings.

Copper Refining in Australia.—The Electrolytic Refining & Smelting Co. of Australia, Ltd., has been formed and registered in New South Wales, with a capital of £150,000, for the purpose of treating and smelting ores and mattes containing copper, gold and silver and of refining electrolytically blister copper produced by the company's own smelting works and other smelting works in Australia. The office of the Electrolytic Refining & Smelting Co. will be at 118 Pitt Street, Sydney. One of the directors is Capt. G. A. Richard, general manager of the Mount Morgan Gold Mining Company, who was recently in this country, accompanied by their chemist and assayer, Mr. B. du Faur, and attended the meeting of the American Electrochemical Society in Philadelphia. The Mount Morgan Gold Mining Co. was formerly one of the largest gold producers of the world and is now a very large copper producer. The intention of the Electrolytic Refining & Smelting Co. of Australia, Ltd., is to erect a large plant in some suitable central position and thereby to start practically a new industry for Australia. The Mount Morgan Copper Company of Queensland, in consequence will relinquish the intention of erecting its own electrolytic refinery at Mount Morgan in favor of joining the new company. Mr. Benjamin Magnus, formerly with the Anaconda Copper Refinery, the Buffalo Smelting Works and more recently with the Mountain Copper Company, will be the general manager of the new refinery.

Thermit versus Weldite.—A suit was tried recently in England between Thermit, Ltd. (the English company affiliated with the Goldschmidt Thermit Co. of this country) as plaintiffs and Weldite, Ltd., as defendants. Judgment has recently been rendered by Justice Warrington. It appears that "weldite" differs from thermit in so far as mixture of aluminium and silicon is employed instead of the pure aluminium in thermit, and was used, like thermit, for rail welding. Concerning this the judge speaks as follows: "The defendants have beyond question carried out the reduction of oxide of iron in the manner described in the specification, with one exception, namely, that they have replaced a small portion of the aluminium by silicon, another metal capable of reducing iron." The defendants denied infringement and attacked the validity of the patents owned by Thermit, Ltd., on a number of grounds. Concerning the infringement the judge continues immediately after the passage quoted above as follows: "In my opinion the true result of the evidence on this point is that this change is a mere colorable variation, that the reduction, notwithstanding the variation, continues to be substantially a reduction by aluminium such as is described." The judge found, as the result of the whole case, that the complainants are entitled to an injunction as to all the patents. These are thereby fully sustained.

Ferro-Alloys.—In our February issue we noted the formation of the Electro Metallurgical Co. In the meanwhile the works and business of the Willson Aluminum Co. have been acquired by the Electro Metallurgical Co. The official announcement of the Willson Aluminum Co., signed by the president, Mr. J. T. Morehead, reads in part as follows: "We beg to announce that our works at Kanawha Falls, W. Va., have been sold and transferred to the Electro Metallurgical Co. The sale includes our business, good will and patents, so far as they relate to the manufacture and sales of ferro-alloys. Among the numerous patents acquired by the new company from ourselves and others, covering the manufacture of ferro-chromium, ferro-silicon and other ferro-alloys, are our fundamental patents, broadly covering the manufacture, use and sale includes our business, good will and patents, so far as product, and the processes applicable to its manufacture. The Electro Metallurgical Co. has ample capital, an experienced staff and adequate reserve electrical power, and is prepared to maintain the highest standard of quality and to make prompt shipment of its products." The Electro Metallurgical Co. intends to manufacture products of the highest grade, consisting for the present mainly of ferro-alloys low in carbon. The company has an office at 79 Wall Street, New York, but the general offices are located at 157 Michigan Avenue, Chicago, Ill. Mr. E. F. Price is general manager of the company.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBID (*Continued*).

No. 541,138, June 18,1895, Thomas L. Willson, of New York, N. Y.

Crystalline calcium carbid existing as masses of aggregated crystals, having a bluish or purplish iridescence. The described mode of production is that of Willson, 541,137.

Reissue 11,511 of original 541,137, Oct. 22, 1895, T. L. Willson, of New York, N. Y.

The description is corrected to state that the current is reversed fifty times a second instead of fifty times a minute.

No. 552,890, Jan. 14, 1896, W. C. Clarke, of New York, N. Y.

Employs a furnace, the circular wall of which is gradually built up of semicircular or other curved pieces of tile or fire-brick, as reduction of the charge proceeds. In starting, a piece of sheet iron constituting the lower electrode may be placed on the ground and the lowermost layer of the wall placed thereon. The charge mixture, pulverized lime twenty parts and carbon twelve parts, is then introduced and smelted by the use of a depending carbon electrode. When the initial charge is reduced, another layer of the wall is added, the carbon electrode raised and a fresh charge thrown in. The reduction and building up proceeds until the height becomes inconvenient or the resistance too great. The lower end of the carbon electrode is kept near the upper edge of the furnace wall, permitting the hot gases to escape without coming in contact with this electrode, whereby its life is prolonged. The resulting column of carbid, which, during operation, constitutes the lower electrode, is separated from the wall by an unreduced layer. This falls away as the wall is removed and is used, while hot, for a subsequent charge. The carbid as it cools is grappled and removed.

NEW BOOKS.

REPORT ON THE EXPERIMENTS MADE AT SAULT STE. MARIE, ONTARIO, UNDER THE GOVERNMENT AUSPICES, IN THE SMELTING OF CANADIAN IRON ORES BY THE ELECTROTHERMIC PROCESS. By Dr. Eugene Haanel. 150 pages. Illustrated. Ottawa, Ont., Can.: Department of the Interior, Mines Branch.

THEORIES OF CHEMISTRY. Lectures delivered at the University of California. By Svante Arrhenius. Edited by T. S. Price. 212 pages; illustrated. Bound in cloth. Price, $1.75. New York: Longmans, Green & Co.

EXPERIMENTAL AND THEORETICAL APPLICATIONS OF THERMODYNAMICS TO CHEMISTRY. By Walter Nernst. 133 pages. Illustrated by diagrams. Bound in cloth. Price, $1.25. New York: Charles Scribner's Sons.

FIRE ASSAYING. A practical treatise on the fire assaying of gold, silver and lead, including description of the appliances used. By Evans W. Buskett, B. S. 105 pages; 70 illustrations and many tables. Bound in cloth. Price, $1.25 net. New York: D. Van Nostrand Co.

FOODS AND THEIR ADULTERATIONS. By Harvey W. Wiley (Department of Agriculture, Washington). The origin, manufacture and composition of food products, description of common adulterations, food standards and national food laws and regulations. A guide to the chemist in detecting impurities in food. Bound in cloth. 625 pages. Illustrated. Price, $4.00 net. Philadelphia, Pa.: P. Blakiston's Son & Co.

DENATURED OR INDUSTRIAL ALCOHOL. A treatise on the history, manufacture, composition, uses and possibilities of industrial alcohol in the various countries permitting its use and the laws and regulations governing the same, including the United States. By Rufus Frost Herrick. 512 pages; 163 figures. Bound in cloth. Price, $4.00 net. New York: John Wiley & Sons.

INDUSTRIAL ALCOHOL. Its manufacture and uses. By John K. Brachvogel, M. E. (A practical treatise on Dr. Max Maercker's Introduction to Distillation, as revised by Drs. Delbrück and Lange, comprising raw materials, malting, mashing and yeast preparation, fermentation, distillation, rectification and purification of alcohol, alcoholometry, the value and significance of a tax-free alcohol, methods of denaturing, its utilization for light, heat and power production, a statistical review, and the United States law). 500 pages; 105 engravings. Price, $4.00. New York: Munn & Co.

JOURNAL OF THE IRON AND STEEL INSTITUTE. Extra volume for 1906. Edited by B. H. Brough. Bound in cloth. Price, $6.00. New York: Spon & Chamberlain.

THE ANALYSIS OF SILICATE AND CARBONATE ROCKS By W. Francis Hillebrand. 202 pages; illustrated with diagrams and tables. Price, 30 cents. Washington, D. C.: Office of the Superintendent of Documents.

THE VALUE OF PURE WATER. By George C. Whipple. 84 pages. Bound in cloth. Price, $1.00 net. New York: John Wiley & Sons.

THE BACTERIOLOGICAL EXAMINATION OF WATER SUPPLIES. By William G. Savage. 297 pages; 13 illustrations and several tables. Bound in cloth. Price, $2.50 net. Philadelphia, Pa.: P. Blakiston's Son & Co.

HOW TO CHECK ELECTRICITY BILLS. Containing methods of charging for electricity with directions for reading and testing electric meters. By S. W. Borden. 54 pages; 41 illustrations. Bound in cloth. New York: McGraw Publishing Co.

PRACTICAL ILLUMINATION. By J. R. Cravath and Van Rensselaer Lansingh. 370 pages; 400 illustrations. Bound in cloth. Price, $3.00 net. New York: McGraw Publishing Co.

DESIGN AND CONSTRUCTION OF HYDROELECTRIC PLANTS. Including a special treatment of the design of dam. By R. C. Beardsley. 520 pages; 480 illustrations. Bound in cloth. Price, $5.00 net. New York: McGraw Publishing Co.

BOOK REVIEWS.

HYDROMETALLURGY OF SILVER. By Ottokar Hofman. 8vo., pp. X + 345. 82 illustrations. Price, $4.00 New York: Hill Publishing Co., 1907.

A most timely work on an important branch of metallurgy, by one of the men best able to handle the subject. It is true, as pointed out in the preface, that great improvements have been made in chloridizing roasting, the preliminary to most wet extraction methods, and in the use of cyanide solutions on silver ores, and yet the literature of silver has not kept pace with these improvements.

In this work we find, in Part I., 154 pages upon chloridizing roasting, a fuller and more satisfactory treatment of this subject than is to be found anywhere else, but we must confess to some disappointment at the frequent absence of precise figures and the use of such expressions as "require much fuel," "if the heat is too high," "most of the lead." We do not know whether Howe's temperature measurements on the sulphating roasting of silver sulphide were ignored because unknown to the author or because he did not consider them reliable, but we certainly expected to find such precise data referred to in this work. Several important subjects, like the collection of flue dust, are dismissed too briefly.

Part II., containing 190 pages, discusses the extraction of the silver from roasted ore, or from raw ore if suitable. Treatment with hyposulphite solution claims over half this space, and is very practically and clearly written. There is a brief obituary of four pages upon the Russell and the Kiss processes, it being baldly stated that neither of them are a success. For a discussion of these the metallurgist will still have to refer to Statefeldt's "Hyposulphite Lixiviation of Silver Ores."

We are afraid that the author's experience with the cyaniding of silver ores is much less extensive than with the hyposulphite method, for the forty-page chapter on it is practically entirely a compilation; and we cannot agree, in view of the metallurgical revolution which cyaniding has accomplished in Guanajuato, for example, that this process is "more or less in its experimental stage" with regard to silver ores. It is more than probable that the hyposulphite process itself is eventually doomed to practical extinction by the improvements which will be made in cyaniding silver ores. We wish that this process had been given a masterful exposition, for such was needed and should have been found in this volume.

Altogether, our rapidly-expanding metallurgical literature in English has gained new honors by this timely work.

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FIRE ASSAYING. By Evans W. Buskett, B. S., chemist of the Ozark Smelting & Mining Co. 12mo., 105 pages. Price, $1.25 net. New York: D. Van Nostrand & Co.

An elementary presentation of the assaying of gold, silver and lead ores, which first appeared serially in *Mines and Minerals*, and is here rewritten, revised and augmented. The eight chapters deal respectively with sampling, reagents and fluxes, assay of acid ores, assay of base ores, lead assay, bullion assay, methods of handling work and laboratory tests, etc.

The chapter on sampling is well illustrated and is very practical, but some statements are inaccurate, such as the definition of a "salted" sample. The information on reagents and fluxes is condensed, but to the point as far as it goes. The information as to acid and basic ores is hardly sufficient to give the beginner the right idea as to their essential characteristics, the details are too vague and precise figures lacking. The chapter on lead assaying is totally inadequate to teach the subject properly to anyone. The bullion assay is fairly well described. The chapter on methods of handling work contains some very useful directions for the beginner. The laboratory tests are well written.

Altogether, the beginner would learn easily from this book

much about assaying, and would lack very much of being "an
assayer" when he had mastered all its contents.

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ELECTRIC AND MAGNETIC MEASUREMENTS AND MEASURING IN-
STRUMENTS. By Frank W. Roller, M. E., member A. I.
E. E., A. S. N. E., A. E. S., etc. $3.50 net. New York:
McGraw Publishing Co.

Mr. Roller's work should prove a useful reference book
to those who have to do with electrical and magnetic measure-
ments. It is fully illustrated and a useful appendix gives the
names of the makers of the various instruments described in
the text.

The book is divided into three parts, the first dealing with
measurements of resistance, current, potential, capacity, etc.;
the second part describing various recording instruments, and
the third part covers magnetic measurements.

In all cases a brief description of the general construction
and principle of the various instruments is given, which, as
the author points out, will enable the engineer to decide
which are best suited for his general requirements.

The diagrams in the book are very clear, but some of the
photographic reproductions of instruments are not all that
could be desired.

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A TEXTBOOK OF ELEMENTARY ANALYTICAL CHEMISTRY. By
John H. Long, M. S., ScD., professor of Chemistry and
director of the Chemical Laboratories in the Northwestern
University Medical School. Illustrated. Price, $1.25 net.
Philadelphia: P. Blakiston's Son & Co.

This is the third edition of this textbook and has been re-
vised and enlarged.

The author in his preface to this edition says that experi-
ence has convinced him of the practical value of the plan of
the work as originally laid out, viz.: The following up of a
course in qualitative analysis by instruction in volumetric
work. He thus finds that "the knowledge of quantitative chem-
istry which may be imparted in this way in a limited time is
certainly greater than can be given by gravimetric analysis in
the same period."

The new edition contains important additions. Among
these is a chapter discussing in general reactions in solutions,
and there have also been introduced a large number of simpli-
fications in qualitative work.

The book is evidently designed for the use of the general
student, medical, pharmaceutical, etc., and does not profess
to be a textbook for the regular analytical chemist.

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REPORT ON THE EXPERIMENTS MADE AT SAULT STE. MARIE,
ONTARIO, CANADA, under Government auspices, in the
smelting of Canadian iron ores by the electrothermic pro-
cess. By Eugene Haanel, Ph. D. 150 pages; fully illus-
trated. Ottawa, Canada: Department of the Interior,
Mines Branch.

This is the full official report on the now celebrated experi-
ments made last year with the Héroult furnace at the Soo,
under the supervision of Dr. Eugene Haanel, superintendent
of mines and the author of this report. The preliminary report
has been discussed and abstracted at length on pages 124, 265
and 332 of our Vol. IV. The present full report differs from
the preliminary report only in giving a few more details and
a complete record of all the runs which were made.

It will be remembered that after the tests had been con-
cluded the experimental furnace was taken over by the Lake
Superior Power Co. for the purpose of producing ferro-nickel
pig on a commercial scale. The following statements of Mr. E. A.
Sjöstedt, chief metallurgist of the Lake Superior Power Co.,
on the progress of this work (page 94 of the present report)
are interesting. During the four full months from April to
July, inclusive, 1906, the furnace was in continuous operation,
with the exception of such unavoidable interruptions as were

caused at the power plant and for the change of electrodes. The total product of these four months was 154 short tons, the total working time 114.8 days of 24 hours, the average product per working day being 1.3415 short tons.

The mean voltage of the electric furnace was 38, the mean current was 4,800 amps., the power factor 0.919, the mean electric power approximately 225 hp. Hence the output of ferro-nickel pig per 1,000 electric horsepower-days was 5.96 short tons.

During this period the following average amounts of raw material were consumed for the production of one short ton of ferro-nickel pig: Two tons of roasted pyrrhotite (about 2 per cent sulphur content), 1,500 pounds limestone, 1,200 pounds charcoal and 40 pounds of electrodes. The ferro-nickel pig product had an average composition of about 2.75 per cent Si, 0.01 per cent S, 0.03 per cent P, 4 per cent Ni, and 0.8 per cent Cu.

The report proper fills 100 pages of the volume. The balance is filled by an appendix. Valuable and interesting descriptions are first given of eight new furnaces invented by three Swedish engineers, Messrs. A. Grönwall, A. Lindblad and O. Stalhane. The first three furnaces described are induction furnaces, and the special features of their design are means for the reduction of the phase displacement by diminishing the primary magnetic leakage. The other five furnaces of the same inventors are intended for the reduction of ores, and include an induction furnace, a resistance furnace with electrodes and a rotating furnace. Brief notes are also given on the results obtained with the Héroult furnace in Germany, and the proposed new construction of an electric smelting furnace by Mr. R. Turnbull, the Canadian representative of Dr. Héroult, with brief notes on commercial developments with respect to the Héroult furnace in Canada and the United States. As far as new information is contained in this appendix it will be covered in detail in our next issue.

Like the report of the Canadian Commission of 1904, the present volume is handsome, well printed and profusely illustrated, and those who have contributed to this important work, especially Dr. Eugene Haanal, deserve the sincere thanks of the profession. We cannot do better but repeat what the London *Electrician* said editorially concerning the report of Dr. Haanel's commission of 1904: "It stands a monument of legitimate government activity directed with intelligence and achieving its goal."

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ELEKTROMETALLURGIE DES EISENS. By Prof. Dr. Bernhard Neumann. 176 pages; 89 illustrations. Price, in paper cover, marks 7.00 (retail price in New York, $2.35). Halle a. S.: Wilhelm Knapp (column 26 of the German monographs on applied electrochemistry).

Very much has been published in recent years on the electrometallurgy of iron and steel, but, with the exception of the two handsome volumes of the Canadian Commission, the information is scattered throughout the pages of various engineering journals. The present book will undoubtedly be welcome to many interested in this timely subject, as it is the first classified summary of the great progress which has been made. The book is chiefly descriptive and contains hardly anything that has not been published in the columns of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, but this does not diminish the value of the volume as a ready reference book. The descriptions are concise and clear and fully illustrated.

After some historical notes, recent processes and apparatus are described. They are sub-divided into two classes, those which use carbon electrodes (Stassano, Conley. Galbraith and Stewart, Grange, Peterson, Gerard, Harmet, Gin, Neuberger-Minet, Héroult, Keller) and those which do not use carbon electrodes (Kjellin, Hiorth, Schneider, Colby, Fanchon, Gin, Girod). The next four chapters give data on results of operation, quality of products, power consumption, thermal efficiency

and cost of various of the processes. Then follows a brief comparison of electric furnace processes with present metallurgical practice as to the production of pig iron, structural steel and crucible steel; the author takes a conservative stand which is practically identical with that which this journal has taken in the past. The book is concluded by a chapter on the production of various ferro-alloys in the electric furnace.

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DEUTSCHES PATENTRECHT FÜR CHEMIKER. By Dr. Julius Ephraim. 608 pages. Price, in paper cover, marks 18.00 (retail price in New York, $6.00). Halle a. S.: Wilhelm Knapp. (Vol. XXV. of the German monographs on applied electrochemistry.)

This is the most voluminous of all volumes published so far in the series of German monographs on applied electrochemistry; but it does not relate strictly to electrochemistry. It is a compendium of the German patent laws with special reference to chemical inventions, the author being a chemist and patent attorney in Berlin.

One of the best features of the book is that for every legal axiom which is discussed a typical example is given from chemical engineering practice. These examples should be more useful than any lengthy explanations could possibly be to explain to the layman the essential meaning of the German patent law.

Almost all examples were selected from actual cases which came up before the German patent office and are not fictitious. But only a minority refers to electrochemical cases, the majority relating to other fields of industrial chemistry.

To those who need detailed information on the German patent law this book should certainly be of value.

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THE MANUFACTURE OF METALLIC ARTICLES ELECTROLYTICALLY— ELECTRO-ENGRAVING. By Dr. W. Pfanhauser. Authorized English translation by Dr. Joseph W. Richards. 162 pages; 100 illustrations; bound in cloth. Price, $1.25. Easton, Pa.: Chemical Publishing Co.

Of the German series of Monographs on Applied Electrochemistry four volumes have so far been translated by Dr. Richards into English: Engelhardt's Electrolysis of Water, Le Blanc's Production of Chromium and its Compounds, Nissenson's Arrangement of Electrolytic Laboratories, and Pfanhauser's Manufacure of Metallic Articles Electrolytically. Dr. Pfanhauser is a manufacturer of machinery, apparatus and supplies for electrolplating and electrotyping in Vienna. For this reason it is quite natural that the descriptions of the various processes given in the book are accompanied by practical notes and estimates of the cost of operation, such as a manufacturer will naturally always make for his own purposes. They represent a first approximation, and although they refer to European conditions of labor, etc., they are also valuable in this country, since itemized cost sheets are given so that one may change single items according to local conditions.

There are fifteen chapters, dealing respectively with an historical review; baths for copper galvanoplasty; physical properties of the copper deposit; behavior of copper anodes; constants of the bath and calculation of the amount of deposit; industrial plants; particular devices for special purposes and production of uniform deposits; manufacture of metallic powders and the like; manufacture of metallic foil; production of wire, etc.; manufacture of bodies of large size; manufacture of parabolic mirrors; manufacture of tubes; electrolytic etching and electrolytic engraving.

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WELLCOME'S PHOTOGRAPHIC EXPOSURE RECORD AND DIARY, 1907. 260 pages; bound in red cloth; illustrated. Price, 50 cents. New York: Burroughs Wellcome & Co.

A very handsome pocket notebook with a considerable amount of information of use for people interested in photography, especially with respect to developing and methods of determining the right time for exposures.